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THE THREE NEW BATTLESHIPS "Maine," "Missouri" and "Ohio," for which bids were received by the Navy Department on Sept. 1, will probably have speeds of at least 18 knots, as the modified plans of the contractors involving increased speed are likely to be accepted rather than the bids on the original Department plans, which called for a speed of only 15 to 16 knots. The bids received may be summarized as follows:

Newport News Ship-Building and Dry-Dock Co. Ship on Department plan, 15 knots speed, 11,500 tons displacement, to be completed in 31 months, $2,580,000. Ship on builder's plan, 17 knots speed, same displacement, to be completed in 32 months, $2,680,000. Ship on builder's plan, 18 knots speed, 12,500 tons displacement, 32 months' time, $2,850,000.

Wm. Cramp & Sons' Ship & Engine Building Co. Ship on Department plan, 15 knots speed, 11,500 tons, 29 months for completion, $2,650,000; or two such ships, $2,625,000 each. Ship on builder's plan, 17 knots speed, 11,500 tons displacement, 32 months' time, $2,725,000, or two such ships for $2,700,000 each. Ship on builder's plan, 18 knots speed, 12,150 tons displacement, 32 months' time, $2,885,000, or two such ships for $2,870,000 each.

The Union Iron Works. Ship on Department plan, 15 knots speed, 11,500 tons displacement, 33 months' time, $2,674,000. Ship on builder's plan, 17 knots speed, 33 months' time, $2,725,000. Ship on builder's plan, 18 knots speed, 12,200 tons displacement, 33 months' time, $2,840,000.

John H. Dialogue & Son, Camden, N. J. Ship on Department plan, 33 months' time, $2,840,000.

It will be seen from the above bids that the 18-knot vessels will be secured at a trifling increase in cost over the 15-knot vessels, which were originally designed by the Department. The increased displacement, which accompanies the increased speed, is secured by lengthening the vessels 15 to 20 ft. amidships, giving more room for engine, boiler and coal space. It is stated that the coal bunker capacity is increased to from 1,600 to 2,000 tons in the plans for 18-knot vessels offered by the bidders, while the Department plan called for only 1,200 tons bunker capacity.

The design offered by the Cramps proposes Niclausse water-tube boilers; and the Union Iron Works also proposes to use water-tube boilers. The Newport News Co., however, adhere to the use of Scotch boilers, and makes considerable changes in the battery, substituting four 12-in. guns for the four 13-in. of the Department's plan, and eight 8-in. guns for the fourteen 6-in. Ten small rapid-fire guns are also added.

A CARGO STEAMER OF 13,000 TONS CAPACITY has been ordered from Messrs. Swan & Hunter, Shipbuilders, Wallsend-on-Tyne, England, by the Cunard Line, according to press dispatches from Liverpool, England. The dimensions of the vessel ordered are: Length, 560 ft.; beam, 64 ft., and depth, 42 ft., giving her a capacity of 13,000 tons of dead weight cargo, or about 20,000 tons of measurement goods. These same builders now have approaching completion for the Cunard Line the freight steamer "Altonia," of 11,000 tons capacity.

THE NEW U. S. DREDGING STEAMER "Wingate Bay" had her official trial trip for speed on the Delaware River on Aug. 29. The contract requirements were for a speed of ten nautical miles per hour for four hours, under natural draft, and these requirements we are informed in a letter from the builders were fully met. The "Wingate Bay" is a self-propelling hydraulic hopper dredge, and is 140 ft. long, 30 ft. beam and 12 ft. depth. The dredging equipment consists of one 15-in. centrifugal pump which delivers into two hoppers of 250 cu. yds. capacity. The vessel complete was built for the U. S. government by the Bucyrus Co., of South Milwaukee, Wis., and the contract price delivered at Georgetown, S. C., was $73,800.

THE NEW DRY-DOCK OF THE NEWPORT NEWS Shipbuilding & Dry-Dock Co. was begun on Aug. 30 with the formal turning of the first shovelful of earth in the presence of the shipyard officials and a number of visitors. The plans for this new dry-dock were prepared some months ago by Mr. Walter A. Post, General Superintendent of the company, but work was delayed on account of the war. The basin will be 800 ft. long, with a breadth of 80 ft. at the bottom and 148 ft. at the top. The depth will be 41 ft. 8 ins., from the top of the sill, giving 34¼ ft. of water at low tide. The keel blocks will extend 5 ft. above the bottom, enabling a vessel drawing 29¼ ft. of water to enter the dock. The entrance will be 106 ft. at the top and 80 ft. wide at the bottom, with granite and concrete casements. The bottom will be of stone and concrete on a row of piles bracing the entrance at each side. There will be a line of piles, six in width, down the center of the basin, on which the keel blocks will rest, while on each side of this will be a row of four piles, for the docking keel blocks to rest upon. Piles will extend from each side of the dock for a distance of 45 ft., and will be connected with the sides of the basin with crossbars for the purpose of thoroughly strengthening it. The sides of the dock will be cone-shaped concrete walls, with granite facings. At the bottom there will also be concrete with granite facing, laid upon rows of piles, with connecting cross-stringers of huge timbers in both directions. It is estimated that it will require six months to make the excavation for this immense basin, and it is hardly possible that the dock will be completed under twelve months. It will be very near and just to the north of the present dock. With two dry-docks the Newport News & Shipbuilding Dry-Dock Co. will be thoroughly equipped to handle any of the merchant or war ships afloat at any time.

THE CONSTRUCTION OF TWO IRONCLADS for the Norwegian Navy is contemplated by the Norwegian Admiralty, according to reports from the British Consul at Christiana. It is stated by the same authority that the bids for construction will be called for by Oct. 8. Inquiries should be addressed to the Norwegian Admiralty, Christiana.

THE IMPORTS OF CUBA AND PUERTO RICO, says the U. S. Bureau of Statistics, have averaged about $60,000,000 annually for the last decade. Of this about one-half came from Spain, about one-third from the United States and the remainder from England, Germany, France and other nations. Of this total Cuba took about 85%. The fact that Spain commanded the bulk of the traffic was due to the discriminating tariff, now abolished; and under these circumstances the class of Spanish imports is interesting. In 1895 and 1896 the chief Spanish imports, in the order of value, were: Wheat flour, shoes, flax and hemp and manufactures of these, firearms, soap, manufactures of wood, packing and cigarette paper, wax and stearin, bricks, earthenware, butter, rice and leather.

BIDS FOR SMOKELESS POWDER for use on United States warships were received by the Navy Department on Sept. 3. The amount of explosive called for was 1,000,000 lbs., and the bids were made on two propositions: (1) that the government supply the alcohol and ether and (2) that the government supply the alcohol only. The bids were as follows:

	Proposition 1. Cts. per lb.	Proposition 2. Cts. per lb.
Dupont Powder Co., Wilmington, Del.	79½	80
Giant Powder Co., San Francisco, Cal.	90*	95*
Dittmar Powder Co., New York	80*	..
Lewis Nixon, Elizabethport, N. J.	96†	..
Laflin & Rand Powder Co.	79½	80
California Powder Co	..	80

*For 250,000 lbs. only. †For 100,000 lbs., only.

THE BALLOON IN WARFARE seems likely to have seen its best days, in view of the discouraging experience of the United States troops with the balloon at Santiago. It is evidently more foolhardiness to send up observation balloons within range of the enemy's guns; but modern infantry rifles and light artillery can send projectiles so far that a balloon sent up out of range will be too far from the enemy's lines to discover any facts of importance, unless the weather is unusually clear.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment which occurred Sept. 1 on the New York, Ontario & Western R. R., at a point about four miles south of Fulton, N. Y., and which is stated to have been caused by tramps who threw open the switch at which the train was wrecked as well as two switches to the north of the wreck. The train wrecked was a fast passenger train known as the "Chicago Limited" and, it is stated, was running at a speed of 60 miles per hour when it struck the switch and was thrown over to the side track. The rapid speed made it impossible to make the sharp turn and the train left the track. The engine was thrown 20 ft. and badly wrecked; the tender was inverted, and the head coach telescoped the baggage car. A vestibuled chair car and sleeper coming behind were both derailed. The engine driver, fireman and one brakeman were killed and eleven others were injured.

THE EXPLOSION OF A HARBOR DEFENSE MINE in the Mississippi River at New Orleans, La., on Sept. 3, destroyed the U. S. Government snag boat "Meigs" and killed six of the 19 men on board. The "Meigs" was engaged in removing the harbor mines at the time of the accident, and no reason is known why the explosion should have occurred.

A GRADE CROSSING COLLISION between an electric car of the Troy City R. R. and the special boat train of the Delaware & Hudson Canal Co., which occurred at Cohoes, N. Y., on Sept. 5, resulted in the death of 18 persons on the electric car and the injury of nearly as many others, some of whom will probably die. The electric car contained 35 passengers at the time of the accident and was struck fairly in the center by the passenger train which was going at a high rate of speed. The responsibility for the accident has not been determined.

THE COLLAPSE OF TWO 368-FT. PRATT TRUSS spans of the New York & Ottawa R. R. bridge under construction across the St. Lawrence River, near Cornwall, Ont., occurred on Sept. 6, precipitating about 60 persons into the river, of which it is estimated that fully 30 were killed. This bridge crosses the river at a point where the stream is divided into two channels by Cornwall Island. Crossing the Canadian channel a cantilever structure is being erected and crossing the American channel a three-span Pratt truss structure. Both of these structures are designed to carry a single track railway. It was the Pratt truss structure to which the accident happened. The three spans are carried by four masonry piers constructed of rock-faced ashlar masonry, with Portland cement concrete backing. The river piers rest on cribs filled with Portland cement concrete up to within 3 ft. of low water, and the shore piers rest on concrete footings placed in excavations dug 5 ft. below low water. The foundation bed consists of hard compact clay and boulders. At the time of the accident the erection of the span between piers No. 1 and No. 2, numbering from the American shore, had just been completed and the workmen were engaged in removing the traveler employed in the erection. The erection of the other two spans had been completed previously. Accounts differ as to what actually happened, one eye witness asserting that the shore span collapsed first, dragging down pier No. 2 and the next span in its fall, while others state that the foundation of pier No. 2 had become undermined by the swift current, and it collapsed, carrying with it the two spans which it supported. The latter view seems to be the one most generally accepted as correct by the contractors and others on the ground, according to the press dispatches. A strong bit of evidence in favor of the collapse of the pier first is the fact that, according to the press dispatches, not a vestige of the masonry was apparent after the accident, and it seems hardly probable that the falling of the shore span first would have caused such a total collapse of the masonry. In our next issue we hope to present in more detail the circumstances of the accident and such evidence as is available regarding its cause. The contractors for the bridge are the Phoenix Bridge Co., of Phoenixville, Pa., who sub-let the substructures to Sooysmith & Co., of New York, N. Y.

THE CABLE CARS WERE STOPPED on Broadway, New York city, between the Battery and 35th St., for nearly ten hours, on Sept. 5, from a most unusual cause. The chimney of the Houston St. power station is 14 × 4 ft. in interior cross-section. It is built of red brick and lined with a thin lining, only 4½ ins. of fire brick, this lining being bonded to the red brickwork. There is a damper in the chimney, operated automatically by the steam pressure. At 2 a. m. on the morning of Sept. 5, when the damper happened to be nearly closed, a portion of the fire-brick lining fell on it and jammed it so that it could not be opened. The draft of the boilers being thus choked, the steam supply to the engines soon failed, and the cars stopped running. Several cartloads of brick and mortar were removed from the bottom of the chimney, and it was nearly noon before the cable cars were started. In the meantime horses, horsecars and drivers were secured, and for about four hours from 7.30 a. m. a horsecar service was run.

AN EXPLOSION OF CELLULOID at the works of the Celluloid Mfg. Co., of Newark, N. J., on Sept. 4, and the fire caused by it, resulted in the injury of 40 persons, three of whom are pronounced fatally injured. The explosion occurred in the celluloid scrap house, and the only reason for it so far determined is the prolonged and intense heat of the past week.

WATER PURIFICATION AT WILMINGTON, DEL.

A unique system of water purification has been in use at Wilmington, Del., since the latter part of 1894. Upward filtration is employed at the rate, as designed, of 43,560,000 gallons per acre, or 1,000 gallons per sq. ft. of filter bed. The water is treated with iron before filtration, and is aerated both before and after passing the beds. The ordinary cleaning of the beds is effected by washing the filtering material while in place with both air and water. The prototype of this filter was built at Tacoma and is said to be still used at times of bad water.

Wilmington has had a public water supply since 1804. The original works were built by a company, which sold them to the borough in 1810 for $10,000, Wilmington thus being the pioneer American city in changing from private to municipal ownership of water-works. The population of the city increased from 42,478 in 1880 to 61,431 in 1890, and is now estimated at from 70,000 to 75,000.

The water supply is taken from the Brandywine Creek, being pumped from the clear water well to storage reservoirs, with repumping for a small area of high service. Although the creek has for years past received more or less organic pollution it is doubtful whether filters would have been put in as soon as they were had it not been for the large amount of suspended matter carried by the stream. The evils of pollution were officially recognized a number of years ago and steps taken to remove them, as described later in this article. It has been the practice for some time to shut down the pumps when the water is at its worst, drawing the supply from the storage reservoirs meanwhile, but these have a combined capacity of only 40,000,000 gallons, and it is, of course, desirable to keep some water in reserve. The average daily consumption for a number of years has been nearly 6,000,000 gallons, while at times the maximum consumption for several days has been much larger. Of course the maximum consumption is very unlikely to be coincident with heavy rains and turbid water, but it is not safe to count on being able to shut down the pumps for more than four days at a time.

The filter plant was designed by Mr. George H. Sellers, late Manager and Engineer of the United States Filtering & Purifying Co., Girard Building, Philadelphia, but a resident of Wilmington until his death some two years ago. Day labor was employed for the construction of the plant, which was under the supervision of Mr. Sellers and of Mr. Joseph A. Bond, Chief Engineer of the Wilmington Water-Works.

The plant consists of five filter beds, each 16 × 125 ft., and each supplemented by ducts and pipes used for aeration and the devices for adding iron to the water. Each bed is designed for a capacity of 2,000,000 gallons in 24 hours, making a total capacity of 10,000,000 gallons, with no allowances for beds out of use for cleaning. The combined

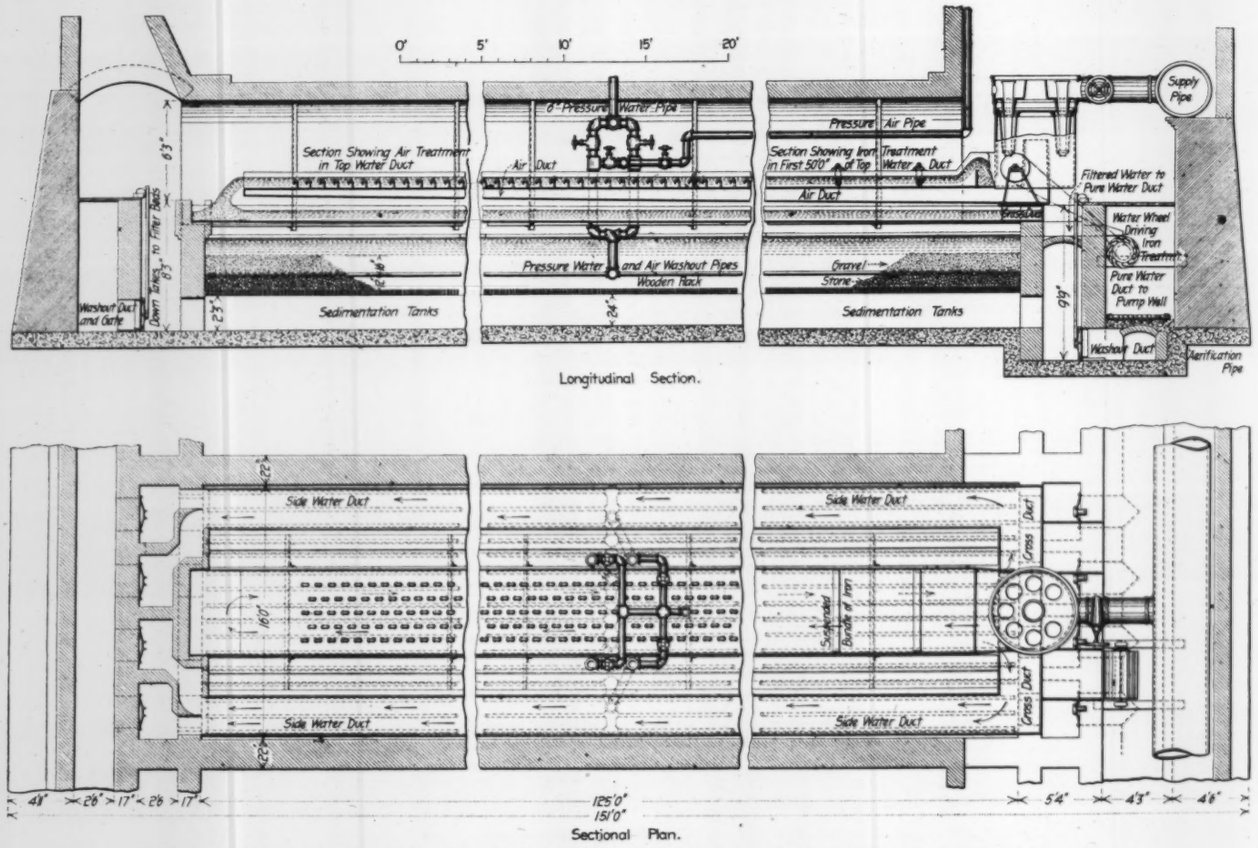


FIG. 1.—PLAN AND LONGITUDINAL SECTION OF WATER PURIFICATION PLANT AT WILMINGTON, DEL.
Geo. H. Sellers (deceased), Engineer; Joseph A. Bond, Chief Engineer Water-Works.

area of the beds is 10,000 sq. ft., or less than one-fourth of an acre, making the rate of filtration 1,000 gallons per sq. ft. per day, or over 43,000,000 gallons an acre, with no allowance for cleaning.

A plan and sections of one of the beds are shown by Figs. 1 and 2. Water passes from the supply pipe down into a number of conical tubes, intended to suck in air with the water, and thence into a flume, where the water first comes into contact with ten bundles of revolving iron rods and afterwards has air admitted to it through the goose necks shown in the longitudinal section. After passing the length of the first flume the water returns through another one, directly below it. More air was introduced here until quite recently, when the air pipes for the lower flume were taken out, on account of the difficulty experienced in keeping them open. It then divides into two parts and flows the length of the filter bed the third time, through the two side flumes shown in the cross-section. After having flowed through the 375 ft. of flumes the water passes down beneath the filter beds into the compartment entitled "sedimentation tanks." From here the water passes upward through the filter bed and out at the end it entered, after a journey of 500 ft. The filtered water for each bed passes over a copper water wheel 2 ft. in diameter and 3 ft. in length, which turns the bundles of iron rods, the power being transmitted by means of a link belt chain. Before the water goes to the pumps air is again admitted to it through a 2-in. perforated pipe, shown at the right hand end of the longitudinal section.

Scrap iron was first used instead of iron rods, about 1,600 lbs. to each bed. This was placed in square boxes and when the corners of the latter were down the increase in power required to turn them gave a jerky motion and caused the boxes to break. The rods are suspended in a chain belt. They are of common iron, about ¾ in. in diameter, and there are about 300 lbs. of iron in each bundle, or 1½ short tons in each bed. The bundles of rods make about 6 revs. per min. The attrition of the rods as they revolve on each other was designed to cause particles of iron to be deposited in the water to serve as a coagulant. The water department has no records of the amount of iron consumed in the process, but Mr. Bond states the rods have not been renewed for two years or so. Had the rods been entirely consumed in two years iron would have been used at the rate of about 0.025 grains per gallon of water. In the Anderson process of iron treatment 0.1 and 0.2 grains per gallon are taken up by the water, according to the printed matter issued by the company controlling that process.* The lower of these two rates, or 0.1 grain per gallon, would require 14.3 lbs. of iron per 1,000,000 gallons of water filtered, or 57,000 lbs. of iron for the past two years, against the 15,000 lbs. put in place two years ago, and still but little wasted. The rubbing of the rods together as they revolve seems to do little more

See p. 241, "Public Water Supplies," by Jno. W. Hill. Also see Eng. News, Feb. 14, June 6 and Sept. 5, 1885, Jan. 1, 1887, April 25, 1891 (under Society Proceedings) and Sept. 22, 1892. The Anderson process is in use in a number of places abroad.

than keep them somewhat polished, judging from the looks of the outer rods. The scrap iron, while in use, showed more wear than the rods, as would be expected.

When the plant is working at its full capacity of 10,000,000 gallons in 24 hours, or 2,000,000 gallons per bed, the time taken for the water to travel from the last bundle of rods to the sedimentation chamber is stated to be about 3½ minutes, and through the whole plant about an hour.

The air for aeration was furnished by a Clayton air compressor with an 18×24-in. air end until about two years ago, when a No. 4 Wilbraham-Baker blower was substituted. The blower is run by the water wheel that drives the power pumps, thus saving power, besides which the air is always available now, whereas the compressor had to stop as soon as the steam plant shut down.

The volume of air supplied is said to be about equal to the volume of water treated, doubtless meaning air at atmospheric pressure.

Originally, one whole filter bed was washed during each twelve hours, except that no washing was done for the last half of Saturday and all of Sunday. A little calculation will show that under this plan the periods between washing each bed would be alternately 2½ and 4 days. In 1896 each bed was divided into halves by plank partitions, so that only one-tenth instead of one-fifth of the plant need be thrown out of use for washing. In addition, washing is done each day now, with a "long wash" on Sunday. The filtering material was also removed and washed in 1896, one bed at a time, the "gravel and sand," to quote from the report for that year, "were again separated into their various sizes and replaced, their comparative depths (being) changed from 17 ins. of gravel and 12 ins. of sand to 12 ins. of gravel and 16 ins. of sand." This is the only time the filtering material has been taken out, washed and screened, Mr. Bond states, but reference is made further on to a clogging of the beds in 1894 or 1895, which necessitated the removal of the material.

The original intention seems to have been to cleanse the filtering material with water admitted from above under a head of 1 ft., alternated with air admitted under pressure from beneath. In the latter case the water would still be passing upward through the bed, as when in use, but the water would be wasted. Mr. Bond stated that the air disturbed the bed by pushing the material upwards and the water carried the fine material downward. Subsequently perforated pipes were placed in the filter beds, as shown in the plan and sections. To wash the gravel the beds are now left submerged and water is wasted from below, while to wash the sand the sedimentation tanks are left filled with water and waste weirs are opened above the beds, so that the air or water, as the case may be, is forced upwards through the sand.

While filtered water has always been used for washing, as we understand it, water under pressure has been used for only about 1½ years, so that previous to this change the amount of wash water was unknown.

In 1897 the amount of filtered water used for washing was 53,183,250 gallons, or 2.6% of the total pumpage. The total amount of water pumped from the Brandywine, all of which we suppose was filtered, during the three full years the purification works have been in operation, together with the average daily pumpage, is as follows:

Year.	Pumpage, gallons. Total.	Daily average.
1895	2,127,600,000	5,830,000
1896	2,058,000,000	5,640,000
1897	2,041,000,000	5,600,000

There are no records of the amount of material retained by the sedimentation tanks. Every time downward washing is employed some of the sediment, if any, goes out. If necessary the sediment is further removed by the use of a stream from a hose, but this operation is not often required.

The cost of operating the filter plant is not given in the reports of the water department, but it is stated in the report for 1897 that the "expense for maintenance" for that year did not exceed "one dollar per million gallons filtered." Maintenance in the words quoted probably means all operating expenses. In the financial reports entries are made yearly under "filter account" and "filter maintenance." The former appear to include construction expenses, and the latter supplies for repairs and operation. The items under these two headings in the reports from 1893 to 1897, inclusive, are as follows:

	Filter acct.	Filter maintenance.
1893	$52,546	....
1894	38,736*	$158
1895	3,619	772
1896	4,720	425
1897	765	528
	$100,386	....

*Including $2,180 for filter house.

To the figures in the last column should be added labor, and possibly some other items, to obtain the actual cost of operation. Originally one man at $12 a week, or $624 a year, did all the work of running the filters. He now has a small amount of assistance from a laborer employed about the pumping station at $9 per week. The filter man is on duty from about 6:30 to 11:30 a. m., and from 6:30 to 11:30 p. m. No charge is made against the filter plant for the power required to supply the air for aeration nor for electric lighting. At 4% the annual interest charges on the cost of construction would be about $4,000, or about $2 per 1,000,000 gallons filtered.

Assuming the plant able to work at its rated capacity of 10,000,000 gallons per day, the cost of construction, including subsequent changes, would be about $10,000 per 1,000,000 gallons. But in the report for 1895, after the filters had been in use for less than a year, Mr. Bond recommended that their area be doubled, setting forth his reasons as follows:

> The capacity of the filter now in use, although in excess of the consumption, is insufficient to supply the pumps when they are running at their normal speed, and to decrease the speed of the pumps is poor economy, and to force the filter beyond its rated capacity is detrimental to the purity of the filtered water. If the filter area were enlarged, the rate of filtration could be lessened, and the quality of the water would be improved; besides increased facilities would be afforded for cleansing the beds, which is the secret of the efficiency of all filters. A filter of equal area to the one now in use could be built on grounds below the pumping station at a greatly decreased cost.

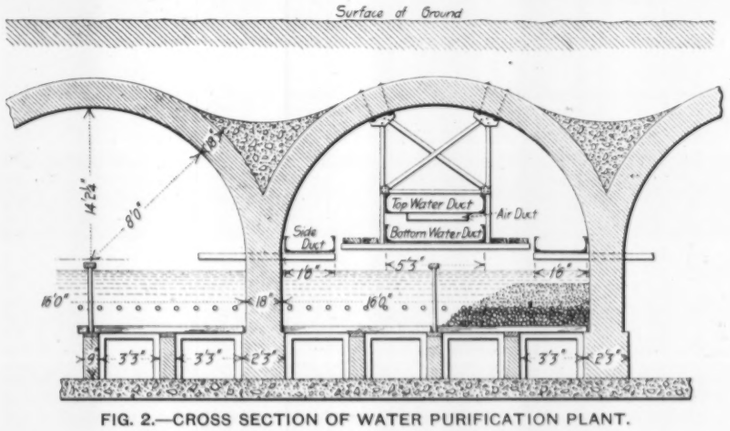


FIG. 2.—CROSS SECTION OF WATER PURIFICATION PLANT.

In explanation of this quotation Mr. Bond states that the 2,000,000-gallon water power pump is always used when any pumping is being done. This, with the 10,000,000-gallon steam pump, gives a daily pumpage of 12,000,000 gallons, which is 20% in excess of the rated capacity of the filters and 33⅓% above their capacity when a half bed is being cleaned. Under the first plan, when a whole bed was cleaned at a time, the rated capacity of the plant was reduced to 8,000,000 gallons, making the pumpage 50% in excess of the capacity of the filters. An automatic gate is provided for admitting unfiltered water to the clear water well, if necessary to supply the pumps, but Mr. Bond states that with upward filtration all the water the pumps will take can be got through the beds.

It has already been stated that the pumps are shut down when the water is very turbid, a practice followed before the filter plant was installed. This not only relieves the filters of much work, but gives them occasional resting spells. In 1894 or 1895, Mr. Bond states, it was necessary to pump very turbid water, with the result that the filtering material became so badly clogged that it had to be removed before the filters could be operated again. In view of all these facts, the filter capacity seems to be overrated when placed at 10,000,000 gallons per day and that without particular reference to the degree of purification effected. We shall not attempt to decide the proper rating, and the consequent cost of construction per 1,000,000 gallons actual capacity.

Wilmington has had a generally decreasing amount of typhoid fever, considering its growth in population, during the period for which statistics are available, or from 1881 to 1897, inclusive. The following figures show that this rate has not been notably accelerated, if at all, since the filters were started:

	Approximate population, 1 = 1,000.	Deaths from typhoid fever. Total.	Per 100,000.
1881	44	43	97
1882	46	51	111
1883	47½	32	67
1884	49	45	92
1885	51	25	49
1886	53	25	47
1887	55	37	67
1888	57	32	56
1889	59	30	50
1890	61	55	90
1891	63	35	56
1892	65	29	45
1893	67	44	65
1894	68	29	43
1895	68	27	40
1896	69	15	22
1897	70	23	33

The figures for population are of necessity only approximate. For 1881-1889 they were scaled from a population curve plotted from the U. S. census figures for several decades past. It seems to be well agreed by the city officials of Wilmington that the population of the city has remained practically stationary since 1893, and was about 70,000 in 1897. Since the latter date it is thought that it has begun to increase again, with the revival of industry.

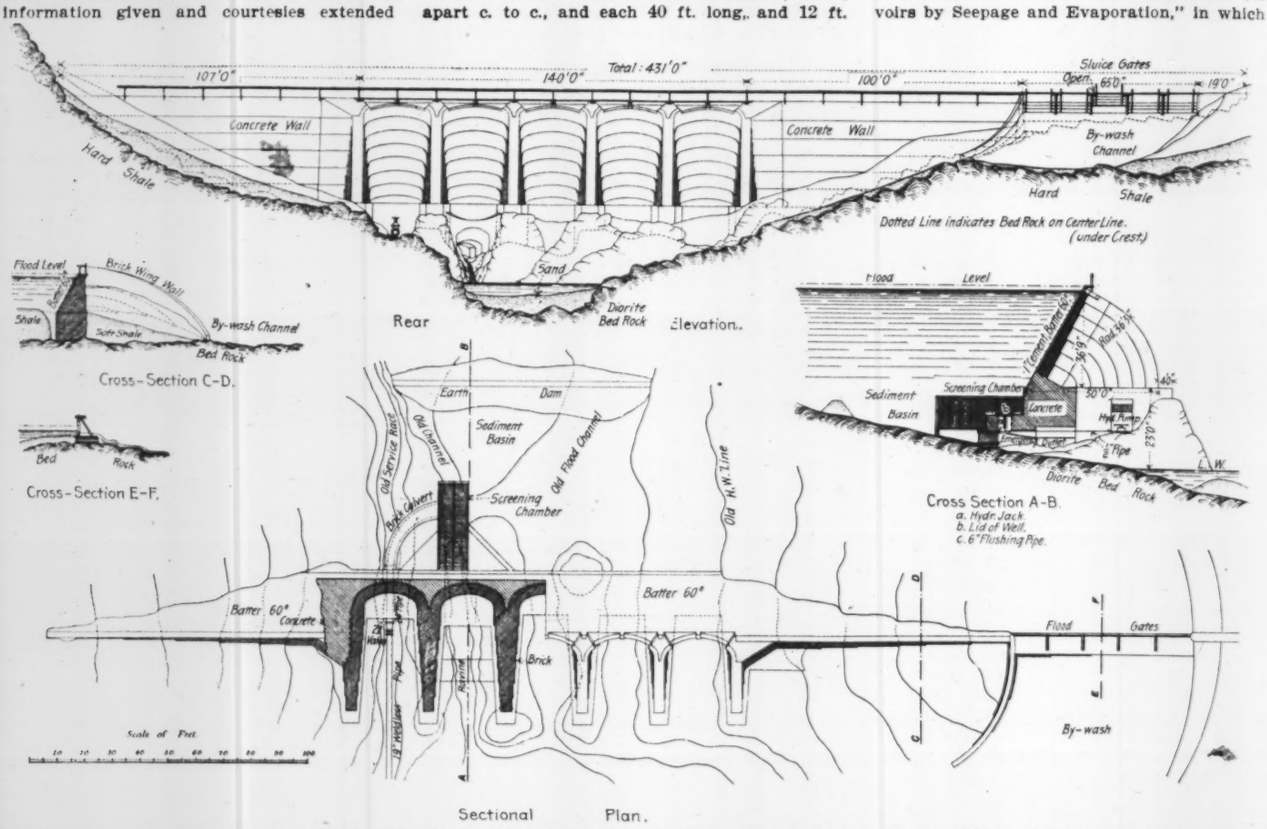
It is to be noted that steps have been taken of late to protect the water supply from pollution. Two sanitary inspectors were appointed in 1894 to give their whole time to the sanitary patrol of that part of the stream within the state. At the start these inspectors had no authority to cause the arrest of persons polluting the Brandywine, but in 1895 this authority was secured from the legislature and is reported as being salutary, although no arrests were made that year and none are mentioned in the later reports.

Some years before the inspectors were appointed, or in 1887, the city diverted, by means of a 20-in. sewer, the waters of two small streams, Rattlesnake and Crooked runs, from the race to a point below the water-works intake. About 1887 the city began the construction of a system of intercepting sewers, which also helped to protect the water supply, although in times of heavy rain the interceptor overflows into the stream above the intake. The sewage at such times is, of course, diluted with storm water and, as has already been stated, the pumps are shut down. Since 1887, also, lateral sewers have been built with rapidity, the water mains have been extended and other sanitary improvements have been constantly in progress. Surface wells have been abandoned with the extension of the water service and those remaining in use are less liable to pollution as the sewerage system comes into more

general use. Credit must also be given to improved care of typhoid patients by physicians and nurses and especially to the control of the spread of the disease through secondary infection. The milk supply, also, is doubtless less responsible than formerly for the spread of the disease.

In the practical absence of analyses of the water both before and since the filter plant was established only general impressions can be gathered from city officials and residents regarding the improvements in the physical character of the water. It seems to be agreed that the plant effects a large amount of clarification, although unable to cope with the water at its worst. Color, or stain, is only partially removed. Complaints of tastes and odors, which were heard for a few weeks some years, seem to have ceased since filtration and aeration was established, the aeration probably being the most effective agent in this connection.

We are indebted to the late Mr. Sellers for the blue prints from which the illustrations have been prepared. We are also indebted to Mr. Bond for information given and courtesies extended to a member of the editorial staff of this journal during a visit to the plant shortly after it was put in operation and again during August, 1898.



BRICK AND CONCRETE DAM WITH BUTTRESSES ON THE BELUBULA RIVER, NEW SOUTH WALES, FOR THE LYNDHURST GOLDFIELDS CO.
Oscar Schulze, Sidney, Australia, Chief Engineer.

THE BELUBULA DAM, NEW SOUTH WALES.

The Lyndhurst-Goldfields Co., of New South Wales, commissioned Mr. Oscar Schulze, C. E., of Sydney, to provide an installation of water power to work large deposits of low grade ore. The water was to be taken from the Belubula River, draining a watershed of 300 sq. miles, with an average annual rainfall of 30 ins. upon it. During the hot season this river is often dry for three months; and under these conditions the dam had to be of sufficient size to impound the water necessary to run three turbines, aggregating 200 HP., for these three months. As described in "Indian Engineering" (from which journal we have also reproduced the accompanying cuts), Mr. Schulze located the dam at a point on the river just above a succession of falls, with a total descent of about 175 ft. At this point the river had cut out a narrow gorge in diorite rock. The valley above this gorge is of such width and slope that a 16-ft. depth of water stores about 87,120,000 cu. ft., and gives a head of nearly 200 ft. on the turbines located about one-half mile below the dam.

The design of the dam is most unusual. The rock at the bottom of the site was found to lie in a number of sharp ridges parallel to the axis of the stream, with deep channels between. A buttressed face-wall was therefore determined upon. The locality afforded facilities for brick-making, and this brick was found to be the cheapest material and the one with which the dam could be most quickly built. Owing to the deep hollows between the ridges of the bed of the stream, an ordinary double-faced wall would have been difficult to construct without expensive foundation work.

The total length of the dam, including overflow, is 431 ft. on the crest; the greatest height is 60 ft., with a concrete foundation varying from 1 to 23 ft. in height and above that 36 ft. 9 ins. of brick work. There are six buttresses, 28 ft. apart c. to c., and each 40 ft. long, and 12 ft. wide where they abut against the wall and 5 ft. wide at the outer end. Each buttress, as carried up in brick work, forms a segment of a circle with a radius of 36 ft. 2 ins., and it decreases in thickness from 8 ft. 6 ins. at the center to 4 ft. on the outer circumference. These buttresses form piers for five elliptical, brick arches, which are 4 ft. thick at the bottom, 1 ft. 7 ins. at the top, and lean forward on an angle of 60°. The spandrels between the arches were filled with concrete, and this concrete covered the crown of the arches to a depth of 12 ins. and joined the side walls of the dam, which were also made of concrete, with large boulders imbedded to save expense. These side walls were built on the same angle of 60° on the water-face, but were vertical on the other, with a top width of 2 ft.

The overflow, built at one end of a side wall, is 65 ft. wide, and is divided into five sluiceways; provision is also made for the water to run over the dam between the buttresses in extreme high water. The arched outlet in the base of the dam, which was left open during construction, is fitted as an emergency outlet by building out a projection on the water-face of the dam with a 5 ft. well in it covered with a 12-in. wooden lid that can be raised by a 50-ton hydraulic ram, worked by a pump at the back of the wall. The 12-in. service outlet pipe is carried through the wall with an entrance made of a tapering and rising brick culvert. The entrances to this culvert and to the two 6-in. flushing pipes are covered by a grating and surrounded by a sediment basin, formed by building an earth dam across the river bed. This same dam diverted the water to the temporary outlet during construction.

The dam contained about 6,000 cu. yds. of concrete and 500,000 bricks, and the total cost of the dam was less than $45,000. To prevent gradual silting up, a cribwork will be built later across the upper end of the valley.

LOSSES FROM IRRIGATION AND OTHER CANALS BY SEEPAGE.

In our issue of June 23, 1898, we published an article on "The Loss of Water from Reservoirs by Seepage and Evaporation," in which we gave the conclusions of Prof. L. G. Carpenter on this subject, as set forth by him in Bulletin No. 45 of the Agricultural Experiment Station, Fort Collins, Col. The same institution has now issued Bulletin No. 48, also by Professor Carpenter, on "Losses from Canals from Filtration or Seepage." This bulletin is based on measurements made under Professor Carpenter's direction, on years of general observation, and on measurements made by others in this and foreign countries. The bulletin may be obtained by applying to Professor Carpenter, or the director of the station. Its conclusions are as follows:

(1) The losses from evaporation are relatively insignificant compared with the seepage losses from most canals. In the cases most favorable to evaporation and least favorable to seepage the evaporation is not over 15% of the seepage.

(2) In the case of reservoirs it was concluded in Bulletin 45 that the seepage was less important than the evaporation. This is different from the results found in ditches, not because the evaporation is less, but because the seepage is much more.

(3) The losses are sometimes enough to cover the whole canal 20 ft. deep per day.

(4) The loss in clay soils is less than in sandy or gravelly soils, but rarely as small as 3 ins. daily.

(5) The loss is greater when water is first turned in than after the bed has become saturated.

(6) Sometimes the canals are found to gain for the whole or part of their length, or the canals may act as drains. This is more likely to be the case when the canal is deep in the ground, when crossing lines of drainage, or when located below other ditches or irrigated tracts.

(7) In the prevailing Colorado soil, when not intercepting seepage, the loss may be put provisionally at from 1 to 2 ft. per day over the whole surface of the canal. In clay soils it is less, but still nearly one-half as much.

(8) The loss in carrying water in small quantities is relatively larger than in carrying large amounts. The increased depth of water means increased leakage, but the carrying capacity increases faster than the leakage.

(8a) From the standpoint of economy it is wasteful to run a small head. It is more economical to run a large head for a short time. In the management of small ditches the time system of distribution can be introduced to advantage, saving time and labor as well as water.

(9) It is wasteful to use two ditches or laterals when one would serve.

(10) The loss increases with higher temperature, being about twice as much at 80° as at 32° F.

(11) The loss increases with greater depth of water, but the exact relation needs further investigation.

(12) The loss will be lessened by any process which forms or tends to form an impervious lining or coating of fine material, as of clay or silt. The silt, consisting of fine sand, improves many soils. Clay is better, and especially limy clay, the lime with the clay forming an almost impervious coating.

(13) Cement linings as used in California and Mexico are not warranted by the conditions in Colorado, nor would the weather conditions be favorable. Nor is the use of wooden stave piping for this purpose likely to be profitable in many places in the state, if at all on the larger canals at present. The silting process applied with discrimination will accomplish much at smaller cost.

(14) On small laterals glazed sewer pipes may save annoyance often connected with the carrying of water in laterals for considerable distances, which, with the saving of water, may make its use an object. One of the supply laterals of the Colorado Agricultural College is of vitrified sewer pipe, over 4,000 ft. of 12-in. pipe being used.

(15) Some particular sections in canals are subject to much greater loss than the canal as a whole. Hence water can be saved by locating the leaky place and remedying it. This may be desirable to do while it would be unprofitable to treat the whole canal.

(16) There are many places where it would be advantageous to combine two ditches, by this means saving not only the loss of water, but saving superintendence and maintenance charges. With increased confidence in the accuracy of water measurement, reluctance to such consolidations should lessen.

(17) The depth of losses from laterals is probably greater than in the main ditches. The laterals are less permanent, are steeper, have less silt, and are more poorly cared for.

(18) There must be some arrangement of ditches and laterals which is the most economical for given conditions, so that the aggregate of the losses of the whole system will be a minimum. Certainly the location and arrangement of the laterals for carrying water from the main ditch is worthy of consideration by the management of the main canal, and the importance increases with the size of the canal and the width of the strip it serves.

(19) It is not to be understood that the whole of the loss from the ditches is lost to the public wealth of the state. Some, perhaps much, of the loss, may reappear as seepage in lower ditches or in the main stream and again be used. It is, however, lost to the particular ditch and incidentally is destructive to much land. With all practicable methods of prevention, there will still be abundant loss. It should be to the advantage of the individual ditch to prevent such loss as far as practicable.

(20) A general statement of the total amount of loss of water must be made and accepted with reservation. It would appear that in the main canals from 15% to 40% is lost, and in the laterals as much more. It would thus appear that not much over one-half, certainly not over two-thirds of the water taken from the stream, reaches the fields.* In the most favorable aspect, the loss is great, and is relatively greatest when the loss can be least afforded, viz., when the water is low and the ditches are running with reduced heads.

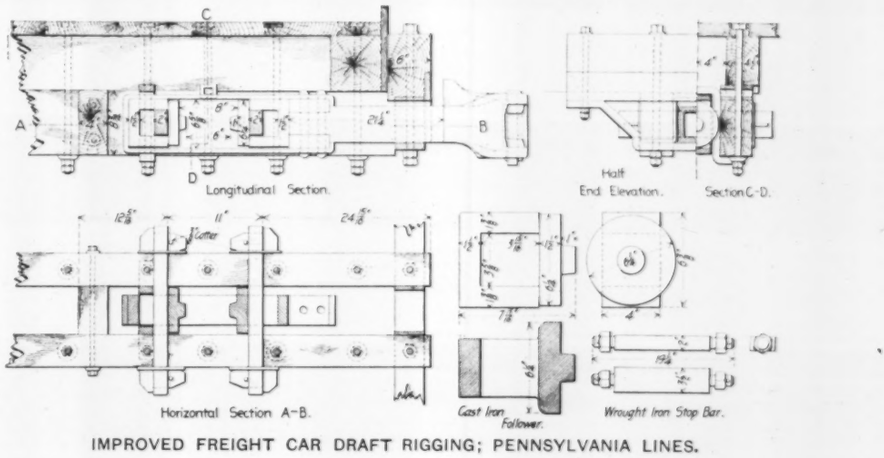
(21) There are some 2,000,000 acres of land irrigated in Colorado, and the value of the water rights, at a low estimate, is as much as $30,000,000. (The census estimates the water rights as worth $28.46 per acre.) On this basis, the capital value of the water lost by seepage in the canals and ditches may be put at from $6,000,000 to $10,000,000. From the evidence at hand at present this seems a low estimate.

A 48-IN. ROTARY VALVE.

The accompanying cut shows the details of a 48-in. rotary valve, made by the Viney Independent Gate Valve Co., Ltd., Lippincott Building, Philadelphia. The two principal advantages of this valve are the quickness with which it can be opened or closed and the small space which it requires. The manufacturers claim that two men can open one of these valves in one-tenth the time required to open an ordinary lift valve. The body of the valve has a diameter only 8 ins. in excess of that of the pipe on which it is placed. This feature is valuable where valves are placed in any limited space, especially beneath street surfaces. In the city of Philadelphia about 150 of these valves, from 20 to 48 ins. in diameter, are placed beneath the streets.

NEW FREIGHT CAR DRAFT RIGGING OF THE PENNSYLVANIA R. R.

About a year ago the Pennsylvania R. R. and allied lines secured the license to use a new draft rigging for freight cars, which promises to reduce materially the cost of maintenance of this class of equipment, draft rigging repairs being generally conceded to be one of the largest items of expense in car repairs. This new device was first tried on a number of cars on the South West System, which ran for a year without showing any signs of weakness in the parts belonging to the draft rigging, after which the Pennsylvania R. R. proper also equipped a number of its cars with the same device. As many of these cars as could be reached were recently examined, and after 1½ years' service their draft riggings were found to be in perfect condition, not a single part needing renewal in the whole lot. As far as known by the officials, not any of these cars have had any repairs done to their draft rigging since they were turned out, nor have any draft springs been found broken on them.



IMPROVED FREIGHT CAR DRAFT RIGGING; PENNSYLVANIA LINES.

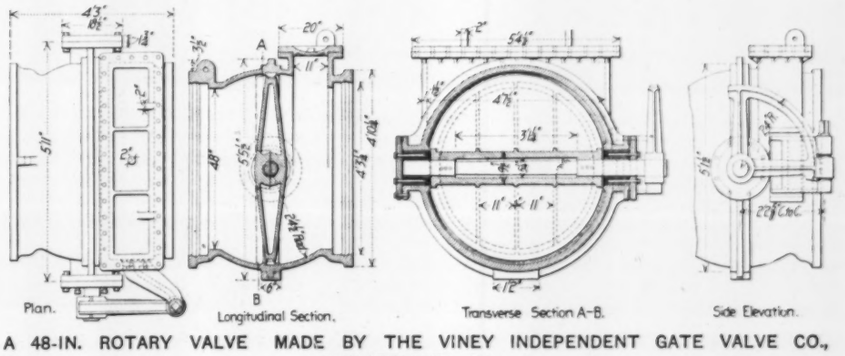
Some of the cars have been exposed to unusually rough handling and have been in collisions, yet it is stated that although the couplers or the cars themselves have been more or less injured, the draft riggings have so far escaped all damage. In one instance, it is stated, a yard engine backed down into a cut of cars, of which the first one had this draft rigging, with such a force that the car, which was a flat car, had all its sills broken in two and the body doubled up like a jack-knife, yet, when the wreck was cleared off the draft riggings at both ends were found intact, draft sills and all, and the complete outfit was applied to another car the next day, without repairing any parts, except straightening some of the bolts securing the draft sills to the center sills.

In another instance a train parted between the engine and the first car, on account of a broken knuckle. The cars bumped up against the tender with such force that the tank shifted 1 ft. on the frame, and the end sills on the first car, which had this draft rigging, broke, but the rigging itself was not damaged. The following two cars, which had a different kind of draft rigging, had it broken, on one car at both ends.

An interesting test was also made at Columbus, O., about a year ago, when two cars with these draft riggings were each coupled to a locomotive headed in opposite directions. The cars were connected by means of a 30-ft. switch rope looped around the knuckle. The engines were then started at full speed, and when the rope tightened up it produced a jerk sufficient to snap off one knuckle by shearing off the pin, cracking another knuckle and bending two other knuckle pins. There was no damage done to the draft rigging of either car.

The strength, which this form of draft rigging possesses, is not, however, its principal advantage, which is the ease with which it can be taken down and put up, and the short time required to renew a coupler, the latter job having frequently been done in six minutes, often without switching the cars out of the train. To do this work it is only necessary to remove the nuts or keys securing the stop bars on one side, and then drive these stop bars through by means of a long stick projecting beyond the side of the car, where there is plenty of room for using a sledge. If a draft spring should need removal, which has not happened yet, however, the back end of the coupler with the tail strap is tipped down on the carrier iron, after the stop bars have been removed.

In the accompanying illustration two different kinds of fastenings for the stop bars are shown,



A 48-IN. ROTARY VALVE MADE BY THE VINEY INDEPENDENT GATE VALVE CO., PHILADELPHIA, PA.

which are both being tried. The one with keys instead of nuts reduces the machine work, and makes it possible to renew all parts of the draft rigging at any blacksmith shop without special tools or formers, which may be a decided advantage for cars that are apt to get out of order at distant points, away from regular repair shops.

It is estimated that this form of draft rigging can be made and applied cheaper than the one in the M. C. B. recommended practice, and it is claimed to have a decided advantage also in that it may be applied to draft sills spaced as close as 5 ins. Another feature is that the spring cannot be compressed solid, which is probably the reason why, so far, no springs have broken. It is understood that the device is to be tried on some new steel cars of large capacity, for which it is considered well adapted on account of its strength.

THE LORAIN SHIPYARD OF THE CLEVELAND SHIP BUILDING CO.

The Cleveland Ship Building Co. has recently completed a shipyard and dry dock, at Lorain, O., 26 miles west of Cleveland, and the entire plant is now in operation. The designs were prepared by Mr. James Ritchie, M. Am. Soc. C. E., of Cleveland, who also superintended the construction. The accompanying drawings show the general arrangement and details of the work. The dry dock has a total length of 560 ft., a width on top of 96 ft. between copings, a width on the bottom of 59 ft., and it will hold a vessel of 500 ft. length on the keel. It is built of timber and piling and has a steel gate, giving an entrance 60 ft. wide on the bottom and 66 ft. on the top, with a depth of 17 ft. of water on the sill at the ordinary stage. The entrance is protected by two timber cribs, and the aprons are of timber on piling. The spaces between the piles are filled with concrete, and the cribs are filled with puddled clay.

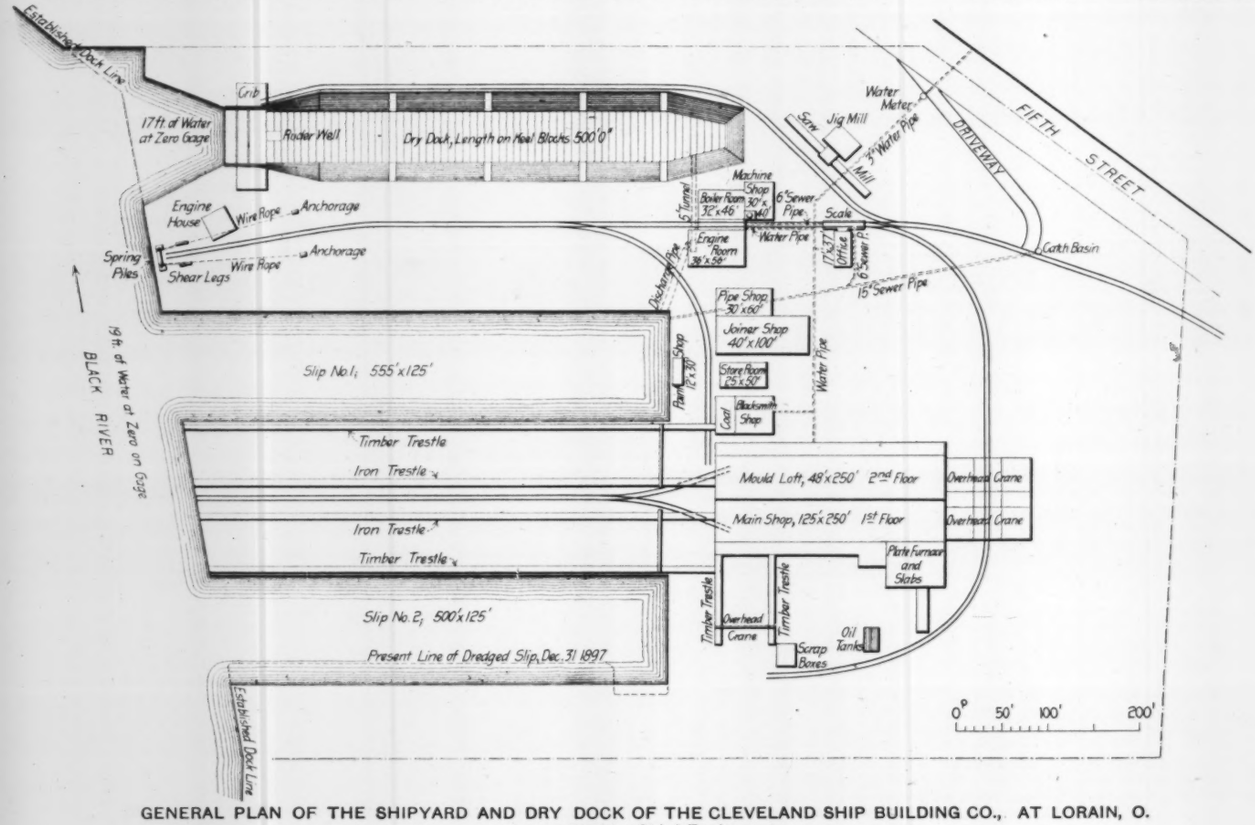
The bottom and slopes of the dock are constructed of piles capped with longitudinal 12 × 12-in. oak timbers. The transverse timbers of the bottom are 12 × 18-in. Douglas fir. There are 63 of these timbers, 50 of them being 64 ft. in length, and the others varying in length from 64 to 32 ft. The slope timbers are 12 × 12-in. and 8 × 12-in. alternately, and 32 ft. long, framed into the transverse floor timbers. The slope timbers are covered by 1-in. pine boards, and upon these are laid the alters or steps. The floor consists of 4-in. pine planks laid on the longitudinal timbers, between the long transverse timbers. There are two drains, one at the foot of each slope, and they unite at the east end of the dock in a cross drain, leading to a brick tunnel, 5 ft. in diameter, which conveys the water to the pumps. The latter are two in number, each having a 30-in. discharge, and together having a pumping capacity of 50,000 gallons per minute. They were built by the Southwark Co., of Philadelphia, and have performed their service with entire success.

The dock is enclosed by a line of 6 × 12-in. tongued and grooved sheet piling, driven 20 ft. into the ground, and anchored to round piles outside by 1¾-in. iron rods. The rudder well is 10 × 15 ft., and 10 ft. deep, with a concrete bottom 24 ins. thick, the sides being protected by sheet-piling. The work of construction was commenced on Feb. 22, 1897, and the first boat docked was the "Sir Wm. Fairbairn," 438 ft. long, on Jan. 26, 1898. Since that date there have been six other large steamers docked with uniform success.

The power-house and main shop are shown on the plans. The shop is equipped with overhead traveling cranes, with all necessary tools for handling and shaping the plates and shapes for the building of ships. Each tool has a pneumatic hoist for handling the material, and all the tools are operated by electricity generated in the power-house, each tool having an independent motor. There are at present two berths for building ships, and over each is a traveling crane operated by electricity, and supported by the timber and iron trestles shown on the general plan between Slips Nos. 1 and 2. The iron trestle is fixed in place, while the timber trestle is movable, and will be taken down when the vessel is ready for launching, as all vessels are launched sideways on the lakes. There will be space for building four vessels at one time in this yard, but only two are now being built.

The sides and ends of the slips and the river front are protected by piling and sheet-piling, anchored back to other piles, by 1¾-in. iron rods. Under each berth are six rows of piles, capped with 12 × 12-in. oak timbers, for supporting the ships during construction. The railroad tracks shown on plan serve to transfer the material from the main line to the various overhead cranes shown on the plan, and everything has been designed with a view of simplifying the handling of material.

The framework of the main shop is of steel construction, with the first floor divided into two rooms, each 40 ft. wide by 250 ft. long, with a passageway between them 15 ft. wide, in each case measured from centers of columns. The clear headroom in this first floor is 18 ft. 6 ins.; and each 40-ft. space is covered by a traveling crane running upon tracks on the four sets of side posts. The mold-loft is located over one-half of this first floor; it is 48 ft. 9 ins. wide, from out to out of side posts, 8 ft. 6 ins. high in the clear, and is covered by a flat, trussed, timber roof, with a 4-ply tar and gravel roof. The other half of the main floor is also covered by a tar and gravel roof laid



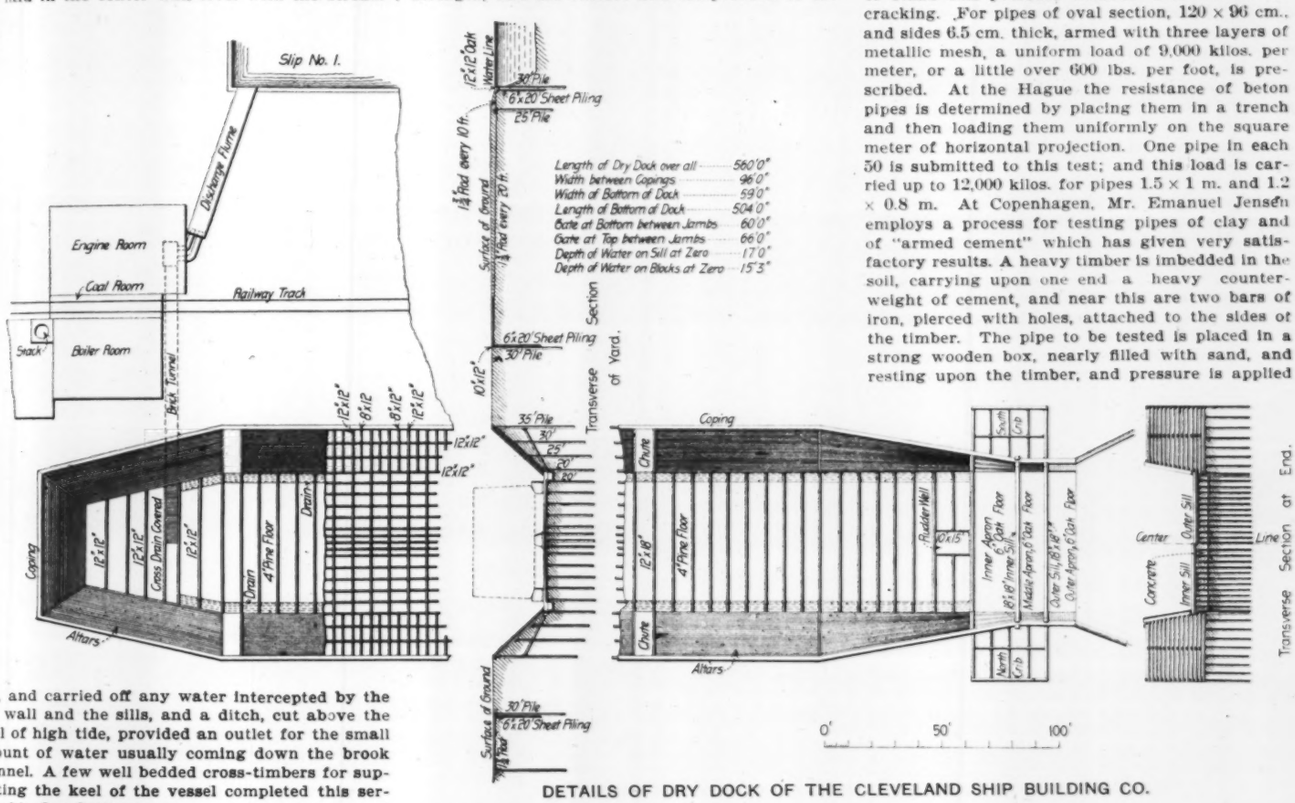
GENERAL PLAN OF THE SHIPYARD AND DRY DOCK OF THE CLEVELAND SHIP BUILDING CO., AT LORAIN, O.
James Ritchie, Chief Engineer.

A NATURAL DRY DOCK.

We are indebted to Mr. T. Hodgson, of Bedford, Province of Quebec, for a description of a natural dry dock and the manner in which it has been utilized. This dock is on the Maine side of the St. Croix River, between Calais and Passamaquoddy Bay. At this point a small brook has cut a channel of sufficient width through the river bank down to about the level of low tide; the difference in tide levels at this place being nearly 25 ft.

As there was a considerable amount of shipping owned in this neighborhood and docking facilities

were absent, some ingenious Yankee concluded that he would utilize the cut made by the small stream; especially as the high range of tide provided all the appliances needed to fill and empty the dry dock. Starting several hundred feet from the river, on the small tributary, a cut was made across the bed of the stream, extending into each bank, and a ten-foot wall of stone laid in cement was built. At the center opening the top of this wall was about on the level of the bed of the stream; but at the sides it extended above the highest tides. Sills were laid in the opening and a pair of ordinary lock-gates were put in place, opening outwards. A pipe controlled by a valve was laid in the center wall level with the stream bed, and carried off any water intercepted by the low wall and the sills, and a ditch, cut above the level of high tide, provided an outlet for the small amount of water usually coming down the brook channel. A few well bedded cross-timbers for supporting the keel of the vessel completed this serviceable dry dock.



DETAILS OF DRY DOCK OF THE CLEVELAND SHIP BUILDING CO.

The operation of the dock was very simple. The vessel came up the river on the flood tide and was hauled into the dock and held in position over the keel blocks as the tide ran out. As the water level lowered shores from the banks kept the vessel upright, and these are found sufficient for the class of vessel using this dock. When the tide had ran out the gates were shut and the water was kept out until repairs were completed. To undock the ship the gates can be opened at low tide and the water thus admitted on the rise of tide will float the vessel, and she can pass out and down stream on the ebb tide. This dock has been in successful operation for some years, and is an interesting example of the utilization of existing natural conditions for securing a much-needed convenience.

EUROPEAN METHODS OF TESTING SEWER PIPES OF CEMENT AND CLAY.

The International Association for the Testing of Materials, in 1896, appointed a committee to investigate the methods of testing sewer-pipes of cement and clay, as up to that time there had been no uniform method of testing, and practice varied widely. Mr. Gary, chief of the section for the tests of materials, at the test laboratory at Charlottenburg, was directed to take charge of this investigation, and his preliminary report is published in "Les Materiaux de Construction," Nos. 23, 24, the official organ of the Association.

Mr. Gary, in 1895, had already investigated, for the German Association of Manufacturers of Portland Cement, the methods employed by governments, municipalities and individuals in testing the strength of cement pipes. He found that these tests varied in each case, and none were regarded as complete for the purpose intended. Similar conditions existed in other countries than Germany.

In the investigation to be made Mr. Gary concluded that the points to be determined were as follows: The resistance to internal and external pressure; impermeability; resistance to the attack of acids; and the wear upon the interior by sand passing with the water. The tests should then mainly determine the bursting and crushing strength, and the texture and composition of the paste used. The resistance to exterior pressure is the most important property in a cement or clay pipe; for, with a few exceptions, such pipes are simply covered with earth or sand, and are not placed in masonry. The pressure upon them will differ as these pipes are laid under traveled streets, under railway embankments, or under the foundation walls of buildings; and it is necessary, in passing judgment upon the fitness of these pipes, to distinguish between the loads to which they are to be subjected in use. Mr. Gary then details the practice of a number of German cities in the test of cement pipe, as follows:

The Department of Public Works of Liegnitz requires that a cement pipe one meter (3.28 ft.) diameter should resist the pressure of a layer of earth 3 meters (9.84 ft.) thick; at Rosenheim, pipes covered with 12 to 16 ins. of earth should resist the pressure of a heavy vehicle; and at Colmar, when there is any doubt of the solidity of a pipe, a loaded wagon is passed over the laid pipe. At Schwerin, in Mecklenburg, cement pipes must resist, without cracking, a pressure equal to 50 kilograms per linear meter and per centimeter of diameter. This test is made by placing railway rails on the top of the uncovered pipe. The city of Freysing prescribes that the pipe should support a "load of 6,000 kilos, concentrated upon the top of the pipe"; and Passau demands that the pipe resist a pressure of 805 lbs. per lin. ft. At Zeitz, where the pipes are buried 6 to 8 ft. beneath the surface, a steam road roller is passed over them before acceptance. Clay pipes, 1 meter diameter, have been tested at Mannheim, by burying them in the earth, with a covering layer about 18 ins. thick. Over the pipe was then placed a double plank platform, about 3 ins. thick in all, and 3.28 ft. square, and on this was placed the test load. The rupturing load was found to be about 28,600 lbs.

For the test of pipes of "armed-cement," or cement reinforced by a double iron mesh on the Zisseler system, the engineer of bridges, at Breme, prescribes the following test: The pipe is buried in sand in a solid wooden box; then by means of a cover fitting inside the box a pressure of 7,500 kilos. per running meter, or about 500 lbs. per lin. ft., is applied to the pipe. The pipe is required to stand this pressure without deformation or cracking. For pipes of oval section, 120 × 96 cm., and sides 6.5 cm. thick, armed with three layers of metallic mesh, a uniform load of 9,000 kilos. per meter, or a little over 600 lbs. per foot, is prescribed. At the Hague the resistance of beton pipes is determined by placing them in a trench and then loading them uniformly on the square meter of horizontal projection. One pipe in each 50 is submitted to this test; and this load is carried up to 12,000 kilos. for pipes 1.5 × 1 m. and 1.2 × 0.8 m. At Copenhagen, Mr. Emanuel Jensen employs a process for testing pipes of clay and of "armed cement" which has given very satisfactory results. A heavy timber is imbedded in the soil, carrying upon one end a heavy counterweight of cement, and near this are two bars of iron, pierced with holes, attached to the sides of the timber. The pipe to be tested is placed in a strong wooden box, nearly filled with sand, and resting upon the timber, and pressure is applied to it by a lever and saddle with the lever support on a pin passing through the holes in the iron bars. The advantage of this process is that the commencement of cracking in the pipe can be noted; though this is of little advantage in the test of clay pipes, as after the appearance of the first crack the pipe will support but little more. But in the case of the Monier and Zissleer construction, where the iron skeleton augments the cohesion of the material, the appearance of the first fissure precedes by some time the final crushing load.

At the test laboratory at Malines, the resistance of pipes to exterior pressure is tested by a Kirkaldy machine; the pipe being placed between two wooden saddles which each embrace one-third of the circumference of the pipe. But as it is difficult to insure contact with all the inequalities of the pipe, the process is not satisfactory.

From the report of Mr. Gary it seems that about the only sewer pipe tests so far employed relate to the resistance against exterior pressure; and he well remarks that a uniform, systematic and reasonable test of sewer pipe, of various materials, has yet to be devised; or, at least, to be introduced, into general practice.

A STEEL CROSS, 88 ft. high and 60 ft. wide, designed to carry electric lights and other decorations will be built and mounted on the Court House tower during the convention of Knights Templar, at Pittsburg, Pa., in October. The trunk and arms of the cross are made of 5 × 3 × ⅝-in. angles, in the form of a lattice column and girder, which is 12 ft. in width.

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We deem it in no way inappropriate to make some reference in these columns to what may well become one of the most notable events of modern times, the formal announcement by the Czar of Russia of an International Conference looking to the disarmament of the great nations of the world, to the extent at least to which their standing armies and navies are a menace to each other. No words of ours can add emphasis to the language with which this absolute ruler of a hundred and thirty millions of people portrays the horrors of war, and the crushing burdens which Europe's vast military armaments impose upon her people. As His Majesty truly says:

> To put an end to these incessant armaments and to seek the means of warding off the calamities which are threatening the whole world—such is the supreme duty imposed to-day upon all states.

The people of this nation, as a whole, will welcome with heartiness this word for peace, spoken by the man who more than any other one man living holds the destinies of nations in his hands. The United States maintains its army and its navy as a means of national defense, and by its fortunate location and its own varied natural resources, it is more secure against foreign invasion and attack than any other nation of the earth. Certainly, this country will never seek to make its military strength a menace to the welfare of any other civilized nation, and its good will toward other members of the great family of nations is such that it should gladly co-operate in every endeavor to increase international comity and reduce the burdens under which European nations now suffer.

The riots at Milan last summer are an indication of conditions in Southern Europe which cannot be overlooked. If civilization is to be maintained, and if governments are not to be swept downward by a wave of anarchy, the crushing burdens under which the people are struggling must be lightened. The vast waste of life and energy and treasure in military and naval armaments must be stopped. Of course, sufficient military forces to preserve internal order and to maintain the governments which civilized nations have established in barbarous lands are a necessity; but the frantic struggle to show superiority over one's neighbor in size of armies or strength of fleets has reached a stage where its burdens are only to be compared to a state of permanent warfare.

The United States, in the full flush of rejoicing over its unparalleled victories in the war just closed, does not forget that its war was fought to bring peace to lands where war, and oppression only less onerous than war, had been the rule for a century. We want no wars, and especially no wars of conquest or aggression; and it is to be sincerely hoped that our government may cordially welcome and do all in its power to further the great reform which the Russian Emperor has set on foot.

The agitation for higher speed in the three new battleships, "Maine," "Missouri" and "Ohio," which was begun in the editorial columns of this journal last June and was continued in the newspaper press throughout the country, receives ample vindication in the bids for the new vessels which were opened at the navy department Sept. 1 and are published on the first page of this issue. It appears from these bids that American shipbuilders are ready to build battleships with a guaranteed speed of 18 knots at a trifling increase in cost over vessels of 1,000 tons less displacement and 3 knots slower speed. No small credit is due to Secretary Long for his fairness and open-mindedness in hearing the arguments in favor of higher speed, and deciding upon the issue of the supplementary circular to bidders, under the terms of which the plans and proposals for 18-knot vessels have just been submitted. That these proposals will be accepted seems hardly open to question, unless, indeed, the naval authorities should decide to reject all these bids and call for new bids for the 13,500-ton battleships which are contemplated in the comprehensive naval program that has recently been framed. In view of the limit of cost, $3,000,000, set by Congress, however, it seems most likely that the present plans for 18-knot vessels will be accepted.

The Engineers' Club of New York city paid a well-deserved compliment to the engineers who have been on active duty with the fleet off Santiago, when it tendered them a dinner on Thursday evening, Sept. 1, at the club's house. It is frequently deplored that in the report of our naval engagements, and in the public mind, small credit is given to the heroes who fight below decks in temperatures that are oftentimes more of a menace to life than the shots from an enemy. It is entirely proper that organizations of engineers should take the lead in remedying this and in according public honors and distinctions to the men whose heroism and devotion to duty are often as great as those of any officers on the vessel, and who contributed in no small degree to the glorious victory won on July 3.

As one of the results of the annexation of the Hawaiian Islands and of the possible large expansion of United States territory, in Cuba, Porto Rico and the Philippines, frequent enquiries are already reaching this office regarding the prospects for engineers in these new possessions. These letters usually come from young engineers, ambitious to force an opening for themselves and anxious to be among the first in the field. While approving of the spirit which prompts this movement, we would advise considerable caution in carrying out the contemplated scheme of seeking professional employment in these remote lands. There is undoubtedly abundant need for engineering enterprise in all of the one-time Spanish possessions; but time must elapse before the conditions are ripe for any radical change of methods which would call for active engineering work. Stable government must be established before capital from the United States will seek investment in these islands; and the people must be made to understand that the misrule of past centuries is at an end before they will be ready to accept and appreciate new methods and new ideas. This means the displacement of well-rooted old ideas; a period of change; and possibly of conflict between the old and the new, which may consume a long time. In this coming revolution in these new possessions, the engineer is doubtless one of the most important factors; but money is absolutely necessary to carry out engineering works, and the conditions must first be such that there is reasonable safety for the investment of money. Our advice to such young engineers is, therefore, to watch capital; to connect themselves at home, whenever this is possible, with those who propose to furnish the means to build engineering works in our new possessions; and to follow the capitalist, and not to precede him. Any other course would probably mean a disheartening struggle, a long wait under unfavorable circumstances, and disappointment. We say probably, because in any field there is usually a chance for a man of exceptional ability and energy or experience; and such a man—on the ground, might find the means for inducing capital to follow him to our new territory. But a man of this type would also succeed equally well at home, where the chances are quite as abundant and the ruling conditions are more favorable. As to the Hawaiian Islands, we would warn our correspondents that American engineers have been for years established there, and at the present time, at least, the supply exceeds the demand. Within a few years, and with the aid of American enterprise, capital and administrative methods, we confidently look for a marked economic advance, in the two West Indian Islands especially; and for the building of railways and highways, improvement in water supply and the sanitation of towns, and in the development of the enormous agricultural wealth of these islands; in other words, there will sometime be abundant work for engineers and a large market for those supplying engineering materials. But while the field is now open for the careful study of engineering possibilities by the experienced man of affairs and engineering expert; the conditions are not yet ripe for the employment of the young engineer who has his experience yet to gain. His chance will come later; when the time arrives for carrying out the plans formulated by the pioneers in the new field.

The recent promotions of the naval officers who participated in the engagements at Manila and Santiago, while well deserved by these officers, have unfortunately done injustice to other officers. By advancing the list numbers of the promoted officers those who are not promoted and who are thus "jumped over" suffer a loss of numbers just as if they had been punished in that manner for some crime or offense against the naval regulations. In many cases an officer who loses some numbers by having other men advanced over him loses his chance of gaining the higher grade and higher pay which he reasonably expects to receive before reaching the age of retirement. It is stated in a press dispatch that Secretary Long will ask Congress to pass a bill to reward brave officers with a medal of honor and an increase of pay of 10 per cent for life, but it is understood that this bill is designed wholly to affect subsequent cases and not to correct the injustice already effected by the promotions. It is to be hoped that the Navy Department may devise some plan, which Congress may approve at its next session, by which the heroes of Manila and Santiago may receive proper rewards without inflicting injustice upon men equally brave but who did not have the same opportunity to show their bravery.

THE SUCCESS OF THE DETROIT MUNICIPAL ELECTRIC LIGHTING PLANT.

The city of Detroit, as most of our readers will recall, has made the largest venture in the way of a municipal electric lighting system of any city in the United States.

The subject of municipal lighting has been extensively discussed and bitterly fought over during the past ten years. Advocates of municipal ownership have magnified the savings which they claimed would be made when cities ceased to rely on private companies to light their streets. The opponents of municipal ownership, on the other hand, have urged that the loss through incompetent and dishonest officials and employees, in the case of municipal plants, would leave the taxpayer in a worse state than when lights were secured by contract.

FIG. 2. VIEW NEAR SUMMIT ON CRIPPLE CREEK DISTRICT ELECTRIC RY.

FIG. 3. PART OF THE WILBUR LOOP; FLORENCE & CRIPPLE CREEK RY.
H. A. Sumner, Locating Engineer.

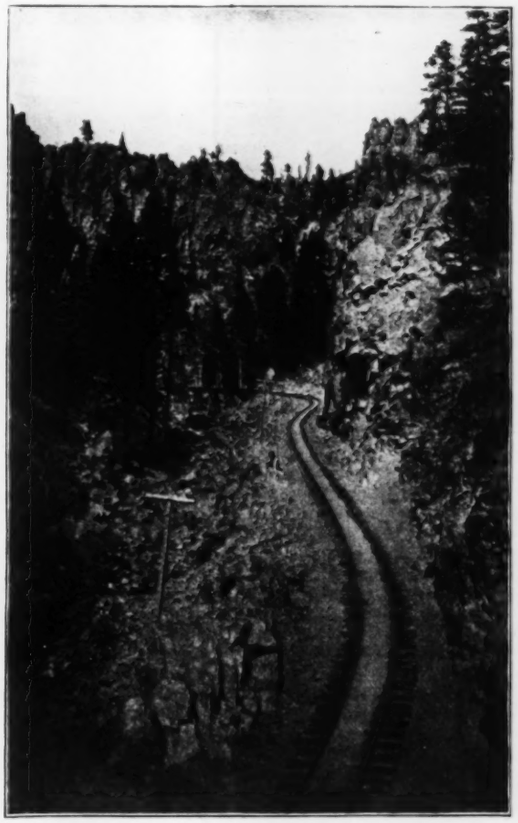


FIG. 5. VIEW ON LINE OF FLORENCE & CRIPPLE CREEK RY.

FIG. 4. CRIPPLE CREEK DISTRICT ELECTRIC RY. NEAR PORTLAND MINE.
W. H. Leffingwell, M. Am. Soc. C. E., Chief Engineer.

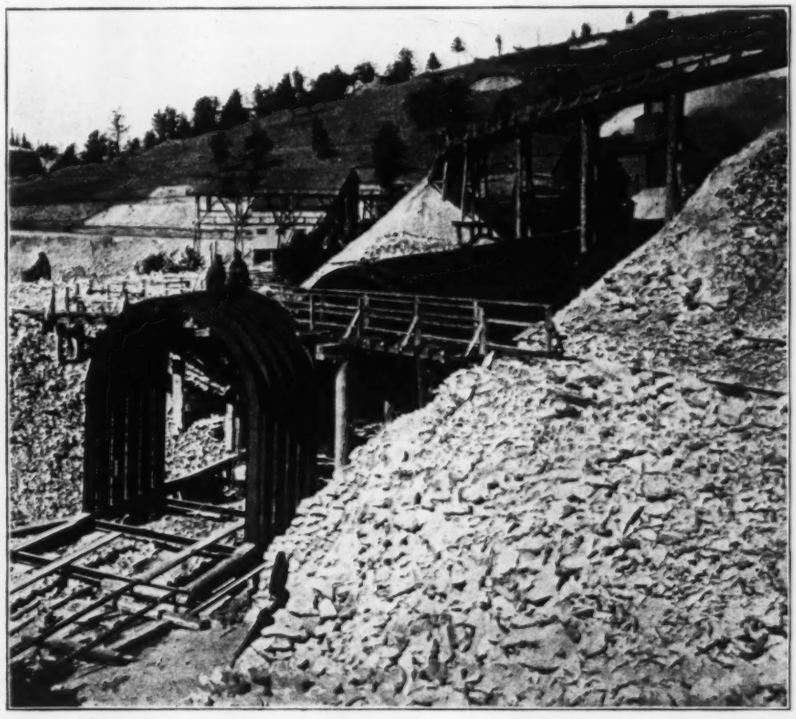


FIG. 1. STEEL FRAME TUNNEL THROUGH DUMP OF THE PORTLAND MINE ON THE GOLDEN CIRCLE R. R.
R. W. Stewart, Chief Engineer.

RAILWAYS IN THE CRIPPLE CREEK MINING DISTRICT.

TABLE I.—Investment and Output of the Detroit Municipal Electric Lighting Plant.

Year ending June 30.	1897.	1898.
Total investment*	$721,400	$771,297
Investment per arc lamp	337.88	293.69
Investment per incand. lamp	18.93	18.52
Plant capacity, arc lights	2,000	2,250
Plant capacity, incand. lights	3,000	3,500
No. arc lights actually operated	1,564	1,744
Same for incandescent	3,064	3,901
Total hours operated, arcs	3,790h. 55m.	3,786h. 20m.
Average hours operated	10h. 23m.	10h. 23m.
Total scheduled lamp-hours, arc	5,873,295	6,505,352
" hours of out lamps	1,371	7,465
" hrs. lamps actually b'rn'd	5,871,924	6,497,887
K-W. hrs. output, arc	2,716,628	2,975,019
" " " incandescent	263,784	306,596
" " " total	2,980,412	3,281,615
Total coal purchased, lbs.	15,032,230	17,075,525
Lbs. used per K-W. hour	5.01	5.23
Cost of coal per ton	$2.06	$1.97
" per lb., cts.	0.103	0.098
" per K-W.hour, cts.	0.516	0.513
Number of men employed	105	93
Total payroll for year	$76,394	$65,660
Total operating expense	110,141	99,713
Cost per K-W. hour, cts.	3.696	3.038
Cost per lamp-hour, arc., cts.	2.3	2.2

*Exclusive of Belle Island.

It is of no small interest, therefore, to see just what results are obtained in practice and see how they compare with those which were so confidently predicted a few years ago. The third annual report of the commission in charge of the Detroit lighting system is before us. It covers the year ending June 30, 1898. As this is the third year of the plant's operation, it may be safely assumed that it is now on a fairly permanent basis. Both machinery and employees are well broken in, and the plant is old enough for the item of repairs and renewals to represent something like a steady figure.

To give first a little of the past history: The Public Lighting Commission of Detroit was created by the Michigan legislature in March, 1893. Its six members were appointed by Mayor (now Governor) H. S. Pingree, with the approval of the city council, and under their direction plans and specifications were prepared and contracts were let for a new municipal street lighting system. The first annual report of the commission, describing the construction of the plant, was reviewed in Engineering News of Aug. 13, 1896.

Turning now to the report of operations for the third fiscal year, let us consider first the cost of the plant.

On June 30, 1897, the total cost of the entire plant, excluding the Belle Island plant ($7,821), amounted to $721,400, or an investment of $337.88 per arc lamp and $18.93 per incandescent lamp, there being at that time a plant capacity of 2,000 arcs and 3,000 16-c. p. incandescent lamps. For the fiscal year ending June 30, 1898, the figures for the same items, also excluding the Belle Island plant ($18,848), are: Total cost, $771,297; investment cost per arc lamp, $293.69; per incandescent, $18.52; using the maximum capacity figures of 2,250 arcs and 3,500 incandescents.

It may be said here that the investment in machinery, etc., which is included in the above total comprises 7 Peck boilers, 5 triple-expansion engines of 240 to 340 HP., 20 arc dynamos of 50 K-W. capacity each, 2 57½ K-W. arc dynamos, 3 Westinghouse engines, 3 55-K-W. two-phase incandescent dynamos, 1,842 arc lamps, 3,901 incandescent lamps, 5,210 poles and 394 miles of wire, and all auxiliary apparatus such as pumps, condensers, feed-water heaters, etc.

In Table I. the figures for investment, output, etc., are given for both 1897 and 1898. It will be seen that the investment per lamp has been considerably reduced through the extension of the lighting system with little or no increase in the power station machinery, and that the operating expenses have been largely reduced. Table II. shows that the economy has been chiefly effected in the item of maintenance, and in shop expense, and the various items in the table will repay careful study by those interested in electric station economy. In Table III. the operating expenses have been arranged as percentages of a total.

It will be seen that station operation and the items connected with maintaining and operating the lamps made up 66.48% of the total operating expenses during 1897, and 74.11% during 1898, or an increase of 7.63%, which was accompanied by a corresponding decrease in other departments. The total operating expenses given in Tables II. and III. show a decrease from 3.696 cts. to 3.038 cts. per K-W. hour of output. There was an increase for 1898 over 1897 in total output of 301,203 K-W. hours to operate 180 arc and 837 incandescent lamps installed during the year.

TABLE III.—Percentage of Operating Expenses of the Detroit Municipal Lighting Plant, Charged to Each Department.

Department.	1897. Wages.	1897. Stores.	1897. Total.	1898. Wages.	1898. Stores.	1898. Total.	Difference in totals.
Maintenance	15.13	4.45	19.58	11.84	4.51	16.35	3.23†
Executive	8.06	.96	9.02	7.69	.83	8.50	.52†
Station	18.95	18.09	37.04	22.07	20.14	42.21	5.17‡
Trimming	21.61	7.83	29.44	22.07	9.83	31.90	2.46‡
Shop	4.13	.60	4.73	.51	.20	.71	4.02†
Injuries & damgs	.01	.18	.19	...	.33	.33	.14‡
Total	67.89	32.11	100	64.16	35.84	100	....

†Decrease. ‡Increase.

It will be seen that the above figures do not give the total cost per lamp per year, which is the basis on which figures for street lighting are most frequently compared. We will ascertain this a little later; but first let us see what arc lamps cost the city when it secured its light by contract.

The average number of arc lamps actually operated and the cost for each year from 1884 to 1894 is given in Table IV., which is reprinted from the report of the Commission for 1896.

TABLE IV.—Number of Arc Lamps and the Cost to the City From 1884 to 1894.

Year.	Total No. of lamps.	Paid to companies.	Average per lamp.
1884	24	$3,650	$152
1885	300	71,982	240
1886	382	91,571	240
1887	565	115,490	204
1888	608	117,370	193
1889	702	128,063	182
1890	719	137,937	192
1891	1,031	133,717	130
1892	1,168	152,283	130
1893	1,279	164,831	129
1894	1,279	169,360	132

In April, 1893, bids were asked for lighting the city for periods of from one to ten years. The bids submitted by the local electric lighting company ranged from $154 per lamp for one year to $102.20 per lamp for ten years; $124 being the price asked for five years. If the ten-year agreement had been entered into, and if the number of lamps had increased at the same rate that actually did occur, Table IV. should receive the following addition:

Year.	No. of lamps.	Addition, total cost.	Cost per lamp.
1895	1,297	$173,538	$133.80
1896	1,483	151,562	102.20
1897	1,564	159,804	102.20
1898	1,744	178,236	102.20

In ascertaining the present actual cost of Detroit's street lighting, it is necessary to consider the matters of interest, taxes and depreciation, which are not included in the figures given in Tables II. and III.

The two previous reports of the commission have both been justly criticised because in their computation of the cost per lamp these items were not sufficiently considered. Thus in the first year's report, interest on the bonds issued to build the plant was included, but no mention was made of taxes or depreciation. In the report for the year ending June 30, 1897, interest and taxes were fairly estimated; but depreciation, for some inscrutable reason, was figured on the boiler plant alone.

In the 1898 report, however, all three items are included, and we find figures as follows:

Interest at 4% on $750,000, which is taken as the average investment	$30,000
Depreciation at 3% on $750,000	22,500
Taxes at $17.68 per $1,000 for city and $3.24 per $1,000 for state on $400,000, the estimated assessed valuation	8,368
Total	$60,868

This, proportioned on the basis of electrical output, gives $55,207 chargeable to arc lighting and $4,660 to incandescent lighting. Dividing the amount chargeable to arc lighting by the number of arc lamps (1,744), gives a cost of $31.65 per lamp per year. Adding this to the operating expenses of $51.85 per lamp per year and we have $83.50 as the total cost to Detroit per arc lamp for the year ending June 30, 1898.

Does this represent fairly the actual cost to the people of Detroit, so that we can fairly compare this figure with the figures for contract service given above, or with the amount which other cities pay for electric lighting?

Concerning the operating expenses, it will be generally agreed that these fairly represent the actual cost of running the works. The only thing which appears at all doubtful is whether the saving in maintenance account has not been made by putting off to a more convenient day repairs and renewals, which ought to have been made to keep the plant in good condition. If this is the case, however, it will show in the expense accounts a year or two hence. The interest estimate is certainly fair, as the city can certainly borrow money at 4%, the rate named. The tax allowance, too, will hardly be questioned by even the most rabid opponent of municipal ownership. When we come to the item of depreciation, however, dispute is sure to arise. Partisans of electric light companies will assert, we presume, that 7% to 10% is the least that should be allowed; and will instance the depreciation which has been experienced in every electric light station established prior to 1890 through the advent of improved machinery. But the past is not always a safe guide to the future. It is true that much of the machinery of ten years ago is obsolete now; but it is by no means certain, or even probable, that the same radical revolutions in electrical industry will be effected

TABLE II.—Operating Expenses for 12 Months Ending June 30, of the Detroit Municipal Lighting Plant.

Charged against	1897. Total.	1898. Total.	1897. Per K-W. hour.*	1898. Per K-W. hour.†	Difference, Per K-W. hour.
Maintenance: Buildings, track, dock, etc.	$810.71	$1,452.86	.....	.....	.....
Steam plant	2,544.64	2,331.16	.....	.....	.....
Electric plant	1,461.29	3,041.19	.....	.....	.....
Miscellaneous tools, machinery, etc.	546.63	725.17	.....	.....	.....
Conduits	1,354.96	697.79	.....	.....	.....
Towers and lamp posts	4,056.26	2,092.38	.....	.....	.....
Arc lamps	3,824.34	2,440.02	.....	.....	.....
Lines	6,982.23	3,525.04	.....	.....	.....
Total maintenance	$21,581.06	$16,305.61	$0.00724	$0.00497	$0.00227
Executive: Salary Sec'y and City Electr.	$3,700.00	$3,799.92	.....	.....	.....
Printing and stationery	962.08	574.44	.....	.....	.....
Store room	1,219.71	1,145.61	.....	.....	.....
Clerk's and office expenses	2,339.96	1,551.59	.....	.....	.....
Civil engineering and drafting	1,731.54	1,399.01	.....	.....	.....
Total executive	$9,953.29	$8,470.57	$0.00333	$0.00258	$0.00075
Station: Oils	$1,445.55	$1,058.16	$0.00049	$0.00032	.....
Waste	250.68	212.67	.00009	.00007	.....
Coal	16,717.15	17,857.72	.00561	.00544	.....
Miscellaneous supplies	2,396.29	954.50	.00070	.00029	.....
Wages	19,966.69	22,004.39	.00681	.00670	.....
Total station	$40,776.36	$42,087.44	$0.01370	$0.01282	$0.00088
Lighting: Trimming and patrolling	$23,256.76	$20,628.71	.....	.....	.....
Carbons	7,118.05	7,765.82	.....	.....	.....
Incandescent lamp renewals	662.33	956.70	.....	.....	.....
Incandescent lamp expense		453.16	.....	.....	.....
Globes and nets	492.90	460.61	.....	.....	.....
Miscellaneous	95.66	495.17	.....	.....	.....
Belle Isle Park	.....	1,045.30	.....	.....	.....
Total lighting	$32,411.38	$31,805.47	$0.01088	$0.00969	$0.00119
Shop expense	$5,207.79	$716.39	$0.00174	$0.00022	$0.00152
Injuries and damages	211.50	327.70	.00007	.00010	.00003
Total expense	$110,141.38	$99,713.18	$0.03696	$0.03038	$0.00658

*Total K-W. hrs. output, 2,980,412.
†Total K-W. hrs., output, 3,281,615.

in the ten years to come. There was a time when progress in steam engine design was exceptionally rapid, and the old throttling low-speed engines were fast made obsolete by the automatic cut-off engines of the Corliss type. But at the present time there are many engines running which were built before 1880 and doing excellent and economical service too.

Let us see what a 3% allowance for depreciation means. It means that if 3% of the cost of the plant is laid aside each year and invested in a sinking fund, with interest at 4%, then at the expiration of between 21 and 22 years that fund will have accumulated to an amount equal to the cost of the plant. Of course, the plant itself will not be valueless at that time. A considerable part of it will be worth nearly as much as to-day, but we may fairly offset the value which it will then have against the increase in the cost of repairs which may be expected as the plant grows older.

Now, the question is whether 21 years is too long a time to set for the average life of the plant. We are inclined to think that it is, and that a depreciation allowance of 4%, corresponding to an average life of a little less than 18 years, would be a more accurate estimate to determine the actual cost of electric light in Detroit.

There is one other item which ought to be included in the Detroit plant's expense account to determine the actual cost, and that is insurance. True, the city does not insure the plant, and we do not question its wisdom in adopting this course. Nevertheless, the element of risk of loss by fire is as much an item in the cost of producing electric light as it is in any manufacturing industry.

Suppose we allow an extra 1% for depreciation and 1% for insurance on the investment of $750,000, this will add $15,000 to the annual expenses, and will make the total cost per arc lamp per annum, $92.10.

It will be seen from the above that Detroit is certainly effecting considerable saving over what she would have expended had she accepted the bid of $102.20 per lamp, which was made in 1893 by the Detroit lighting company for a ten-year contract. A saving in round numbers of $10 per lamp per year means $17,440 per annum with the present number of lamps. On the other hand, it seems to be clear that the company, in making its bid, named about as low a figure as it could afford and leave itself a profit that would make the business worth doing. The company would have had to pay probably 6% interest as compared with the city's 4%, and it would have had to meet the contingency of failing to secure a renewal of the contract at the end of ten years, which would have left its plant on its hands. Thus it would have been obliged to figure on a much higher rate of depreciation than the city.

On the other hand, the company would have had the great advantage of doing commercial as well as street lighting; and this it seems to us is the weakest point in the operation of the Detroit municipal plant. It is evident on the slightest thought that to furnish electric light to a town or city, at the least possible cost, one concern should undertake both the public and private lighting.

As it is, the city of Detroit appears to be getting its street lighting done more cheaply than any private company would undertake that work unless it were guaranteed a monopoly for a long term of years. Comparison with the prices paid in other cities also results in a favorable showing for Detroit. Table V. is prepared from data given in a circular issued by the General Electric Co., of Schenectady, N. Y., and is interesting in this connection. The prices given are for the winter of 1897, and are averages of practically all the arc lighting plants owned by private companies in the states given.

Comparing the Detroit figures with the average for the 1,045 electric light plants whose operations are covered by Table V., it will be seen that in Detroit the hours per lamp were greater, the cost of coal less, the cost per lamp per year less and the cost per lamp hour considerably less than the average of all stations reporting.

A still more interesting comparison may be made between Detroit's prices and the prices charged in other large cities of the United States, as given in Table VI.

In this table New Orleans, La.; Newark, N. J.; Buffalo, N. Y., and Cincinnati, O., operate practically the same number of lights as Detroit, and coal costs about the same per ton with them. All, however, with the exception of Cincinnati, pay considerably more per lamp per year. In only three cities, St. Louis, Mo., Allegheny, Pa., and Salt Lake City, is the cost per lamp less, and in these cities coal is considerably cheaper than in Detroit.

TABLE V.—Average Cost of Arc Street Lighting in Each State.

State.	Hours per year.	Coal per ton.	Cost per lamp— Per year.	Per hour.
Alabama	4,000	$1.92	$89.00	$0.021
Arizona	3,396	2.30	121.00	.034
California	2,885	7.00	119.68	.045
Colorado	3,413	3.18	129.31	.042
Conecticut	2,730	4.28	86.02	.035
Delaware	4,000	2.32	110.00	.028
Dist. of Columbia	4,000	....	106.00	.027
Florida	2,179	Wood.	117.65	.064
Georgia	3,434	1.36	83.81	.034
Idaho	4,000	Water.	114.00	.028
Illinois	2,789	1.19	77.02	.031
Indiana	2,682	1.79	79.33	.033
Iowa	2,870	1.57	85.73	.032
Kansas	2,734	2.02	97.19	.040
Kentucky	3,063	1.20	88.07	.032
Louisiana	4,000	2.38	127.50	.032
Maine	2,629	5.00	67.50	.031
Massachusetts	2,705	4.05	93.81	.037
Maryland	4,000	3.00	127.75	.032
Michigan	3,465	2.70	77.04	.024
Minnesota	3,133	3.41	98.00	.036
Mississippi	2,179	2.33	102.00	.047
Missouri	2,917	2.54	83.99	.032
Montana	4,000	4.00	130.80	.033
Nebraska	2,894	2.21	109.50	.041
Nevada	3,680	9.50	144.00	.039
New Hampshire	2,583	4.42	81.53	.036
New Jersey	3,615	2.70	105.36	.032
New Mexico	3,275	3.92	123.33	.045
New York	3,387	2.87	93.61	.028
North Carolina	3,572	3.30	97.50	.029
North Dakota	4,000	6.35	120.00	.030
Ohio	3,350	1.56	78.87	.025
Oregon	3,689	....	127.71	.035
Pennsylvania	3,931	1.56	85.75	.022
Rhode Island	2,912	3.85	102.37	.037
South Carolina	3,088	2.65	82.50	.031
South Dakota	3,880	5.50	125.00	.034
Tennessee	4,000	2.08	88.05	.022
Texas	3,472	3.13	108.75	.037
Utah	3,545	2.63	74.90	.023
Vermont	2,254	4.37	84.67	.039
Virginia	3,723	3.07	76.09	.022
Washington	3,479	2.75	127.54	.039
West Virginia	3,089	.90	79.21	.027
Wisconsin	3,057	3.13	81.16	.030
Wyoming	3,545	1.58	166.00	.052
Total average*	3,326	$3.03	$101.18	$0.034
Detroit, 1898	3,786	1.97	83.50	.022

*Forty-six states.

TABLE VI.—Cost of Arc Street Lighting in Principal Cities of the United States.

Cities.	No. of arc lamps.	Hours per yr.	Coal per ton.	Contract per lamp per yr.	Cost pr lamp-hour.
Indianapolis, Ind.	1,100	2,179	$1.25	$85.00	$0.039
Louisville, Ky.	1,219	3,840	1.00	84.00	.022
New Orleans, La.	1,384	4,000	2.38	127.50	.032
Boston, Mass.	2,506	4,000	4.00	127.75	.032
St. Louis, Mo.	2,500	4,000	1.35	74.95	.019
Jersey City, N.J.	1,075	4,000	2.50	99.00	.025
Newark, N. J.	1,565	4,000	1.70	98.55	.025
Brooklyn, N. Y.	3,382	4,000	3.60	124.10	.031
Buffalo, N. Y.	2,500	4,000	2.00	100.00	.025
New York city	3,643	4,000	....	146.00 164.20 182.50	.037 .041 .045
Rochester, N. Y.	2,248	4,000	Water.	91.25	.023
Syracuse, N. Y.	980	4,000	2.25	91.25	.023
Cincinnati, O.	1,510	4,000	2.00	84.90	.021
Allegheny, Pa.	1,037	4,000	.95	74.31	.019
Philadelphia, Pa.	6,500	4,000	2.50	109.00 146.00	.027 .036
Pittsburg, Pa.	1,900	4,000	1.01	96.00	.024
Providence, R. I.	1,800	4,000	....	127.75	.032
Salt Lake City	4,000	4,000	2.75	72.00	.018
Milwaukee, Wis.	718 444	4,000	3.00	92.00 109.00	.023 .027
Detroit, Mich., '98	1,744	3,786	1.97	83.50	.022

LETTERS TO THE EDITOR.

The Title of U. S. Assistant Engineer.

Sir: Several days ago I read the editorial in Engineering News of Aug. 4, on "The Position of United States Assistant Engineers," with much interest. If suggestions are in order, permit me to make one at this late date. It seems to me that the government, or "powers that be," might at least substitute the title "United States Civil Engineer," in place of "U. S. Assistant Engineer." The term "Assistant Engineer" is used by many railway and municipal engineering departments to designate transitmen, levelers, draftsmen, or even rodmen. Hence, among civilian engineers, the title "Assistant Engineer" has come to mean a person holding some such minor position on engineering work.

Of course the term "U. S. Civil Engineer" would not indicate the specialty of an expert, but it would indicate the department of engineering, in contra-distinction to the titles, "U. S. Mechanical Engineer," "U. S. Electrical Engineer," "U. S. Mining Engineer," which likewise seem to me to be very appropriate titles for official use.

Very respectfully yours,
C. E. Sherman,
U. S. Assistant Engineer.

Camp Wheeler, Huntsville, Ala., Aug. 26, 1898.

Large Cast-Iron Wheels for Cars and Engine Trucks.

Sir: We have just noticed in your valuable paper of June 9, an article on "Locomotive Tender and Truck Wheels," in which the statement is made that one reason why American locomotives generally have small wheels is that they are fitted with cast-iron wheels, and it is not easy to make good chilled cast-iron wheels of greater diameter than 33 ins., although some foundries have attempted to cast 42-in. wheels, but with unsatisfactory results.

As we have been making wheels 40 ins., 42 ins., and even 45 ins. in diameter for the past five years, we are a little surprised at the statement, and take this opportunity of advising you of what we have done in making wheels of large diameter. We find from our records that in the last three years we have furnished 356 wheels 40 ins. diameter, 84 wheels 42 ins. diameter and two lots of 45-in. wheels; the 42-in. wheels have been used under both passenger cars and engines, and as we have had two repeat orders for those running under engines, we judge that the service has been entirely satisfactory.

We think we are the only wheel makers in the country who have ever successfully made double-plate wheels 45 ins. diameter, and as these have now been running for over a year under locomotives, we can assume that they were a success.

Very truly yours,
New York Car Wheel Works,
Pemberton Smith, Engineer.

Buffalo, N. Y., Aug. 29, 1898.

(It is interesting to note that such large chilled wheels have been made, but it will be seen that the number is quite small and that they have only been made within the past few years. Their manufacture and their use on engine trucks are certainly exceptional as yet. Whatever may be the present conditions of manufacture, we believe the above letter does not in any way affect our suggestion (which was based upon investigation) to the effect that one reason why the smaller wheels have been so generally used on engine trucks is that there are greater difficulties in the manufacture of the large wheels. We have very good authority for our statement that some of the early attempts to cast 42-in. wheels produced unsatisfactory results.—Ed.)

Spacing Stiffeners in Plate Girders.

Sir: The letter of Mr. Jos. M. Wilson on "Spacing Stiffeners in Plate Girders," published in your issue of Aug 11, does not seem to me to be conclusive; neither do the photographs of the loaded paper model seem to offer "convincing proof" that the web resists by tension only. This was quite thoroughly gone over in the discussion brought out by Mr. Wilson's paper by Prof. W. H. Burr and Mr. Edwin Thacher.* Cutting slits in the web entirely changes the conditions; just as would be the case with a Warren girder of two or more systems of web members, if one of the systems were cut.

The distortions in a plate girder under load are of a nature that do not appear to offer much room for difference of opinion. Consider, for simplicity, one panel included by two stiffeners. The top flange will shorten and the bottom flange will lengthen under the compressive and tensile stresses respectively. Then, considering the tension in the web, the panel will be lengthened or stretched out on the diagonal of the tensile stress, and this cannot possibly take place without a corresponding shortening of the opposite diagonal. The effect of stress on a cross section of the member perpendicular to the line of stress, if not confined, is manifested in both directions, width and thickness; so in the case under consideration only a part of the required shortening could possibly be due to this effect of the tensile stress. Therefore, the web will either buckle or be compressed by compressive stress. Since they do not buckle in ordinary practice the diagonal compressive stress must exist in the web.

I am not prepared to deny that the vertical stiffeners carry some proportion of compressive stress in girders as usually built, even when not subjected to concentrated loads, but where there are two or more courses for a stress to follow (a condition of ambiguity), it will divide itself inversely as the length of the course and directly as the section of the members. In other words, it seeks the shortest course and strongest members.

Since flexure (or buckling) does not ordinarily occur in the webs of plate-girders under service, the relative strength of the webs and stiffeners within the limits of working loads are directly as their sectional areas. In most cases the section of the web is much greater that that of

*Trans. Am. Soc. C. E., Vol. XV., 1886, pp. 431 and 468.

the stiffeners. Therefore, if ambiguity does exist, the web offering the shortest course and strongest section will carry far the greater part of the stress, in accord with Rankine's theory.

If someone who has the facilities would apply an extensometer to a plate girder, this question would be placed beyond discussion, to the benefit of all interested.

Albert W. Buel.

150 Broadway, New York, N. Y., Aug. 15, 1898.

Sir: I note with interest Mr. Jos. M. Wilson's contribution to the discussion on the stiffening of web plates, in your current issue. It requires but little reflection to recognize, however, that the behavior of the paper model is strictly in accord with the generally accepted theory governing the distribution of stresses in web plates.

It is to be remembered that the principal stresses—tensile and compressive—act at right angles to each other at every point in the web plate, and that their lines of action intersect the neutral plane at angles of 45°. The general appearance of these lines of principal stress is shown in Rankine's Applied Mechanics, p 342; also in Merriman's Mechanics of Materials, p. 160, although the lines are not completely drawn in the latter. The most complete discussion, known to the writer, covering this matter of internal stresses in beams, is found in Weyrauch's "Theory and Calculation of Continuous and Simple Beams (1873)," pp. 11 to 20, inclusive, illustrated by excellent diagrams, shown on Plate I., in which the lines of principal shears are, however, incomplete. It is to be observed that all diagrams here referred to, relate to beams of solid rectangular cross-section, and require some modification for flanged girders. The distribution of shear across the web of a plate girder is much more nearly uniform than in the case of a rectangular section without flanges.

From the inspection of any of these figures, it will be evident at once that when the web is cut, as in Mr. Wilson's model, and the latter placed in a position relative to a central load, as in Fig. 2, the continuity of all lines of principal tensile stress is absolutely interrupted at the diagonal slits. Not only can these tensile stresses no longer be properly developed, but in their absence or very imperfect state of development, the tendency of the principal compressive stresses to produce buckling in the web can no longer be effectively opposed. The distortion shown in Fig. 2 becomes, therefore, inevitable and might, in fact, have been predicted from purely theoretic considerations.

In Fig. 1, on the other hand, the principal tensile stresses remain, for the most part, fully operative, although, in this case also, their continuity is, to some extent, broken. It is to be expected, therefore, that, contrary to Mr. Wilson's statement, the web thus conditioned will develop less ultimate strength than if left continuous.

It may be observed, in conclusion, that the step from such a model, however its behavior may be explained, to a claim for the analogy between the stiffeners of a plate girder and the posts of a Pratt truss, is one that can be taken only in absolute defiance of sound theory.

Very respectfully, E. M.

Philadelphia, Pa., Aug. 17, 1898.

Sir: In your issue of Aug. 11 the writer has noted a very interesting communication on the plate girder by Mr. Joseph M. Wilson. The paper model is highly ingenious, illustrating how much better able a thin web is to resist tension than compression along the diagonal of a panel. Cutting the slit, however, prevents the tensile stress from stiffening the web, somewhat under compression, as it ordinarily would.

About a year ago the writer was furnished with a model plate girder by the Gillette-Herzog Mfg. Co., through the courtesy of Mr. Frank J. Llewellyn, Chief Engineer. This girder was built in accordance with the writer's design, and is shown in Fig. 1. In alternate panels the web plate was buckled ⅝-in. before assembling in the form of a very flat pyramid, with the corners rounded off; the edges of the pyramid forming the diagonals of the panel. Evidently were the web stresses, tensile and compressive, distributed as in a beam of constant section, the lateral components of these tensile and compressive stresses would neutralize each other, and the form of the buckle should remain unchanged as the load is applied or removed. If on the other hand there is truss action and the tensile stress is the greater, the buckle should spring in as the load is applied.

Under twenty-eight tons this spring of the buckle was about ⅛-in. and the buckle returned to its original shape as the stress was removed. The load was applied by the screw lever at one end and weighed off at the other. The spring of the buckled web seemed to be the same in the end panel, and the panel next the center, as would be expected, since the shear was the same in each.

Having thus shown that a part of the load is carried in a manner similar to a Pratt truss, the question of how great a part naturally arises. In the design of the experimental girder, by a rough method, the writer figured that a trifle more than two-thirds of the load would be carried in a manner similar to a Pratt truss, and the top and bottom flanges were proportioned accordingly. Thermo-electric measurement of the chord stresses indicated that the results arrived at in designing represented closely the actual conditions. Whether the writer would be equally successful in other and different cases he has not as yet had opportunity to determine. As a further proof of the truss theory, all stiffeners were found to be in compression.

The writer heartily agrees with Mr. Wilson in his preference in designing deep girders in the manner outlined by him, since a web 70×5-16 ins. or 90×⅜ ins. may be compared with the experimental girders as regards the

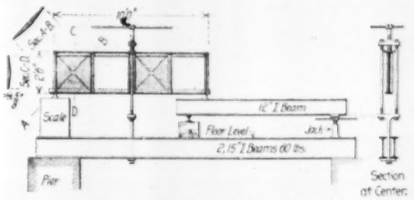


Fig. 1.—Sketch Showing Method of Testing a Plate Girder to Determine Nature of Web Stresses.

ratio of depth to thickness of plate, and with a similar distribution of stress it is evident that cover plates in the top flange should be two panels longer than the corresponding ones on the bottom flange, and that rivets should be distributed in a manner calculated to secure the maximum efficiency of the material used instead of in accordance with a theory at variance with the practical conditions of the case.

The thermo-electric measurement of stress is based on the fact that metal grows cooler on being stretched, and warmer on being compressed, and that the temperature change is proportional to the stress when this stress is well within the elastic limit. The amount of this temperature change may be closely determined by the following formula derived by Lord Kelvin,

$$H = \frac{tpe}{JSW}.$$

Where H is the thermal increase in degree centigrade; t, the temperature centigrade from absolute zero; J, the mechanical equivalent of the thermal unit; p, the pressure applied in pounds, positive if compression and negative if tension; e, the longitudinal expansion per degree centi-

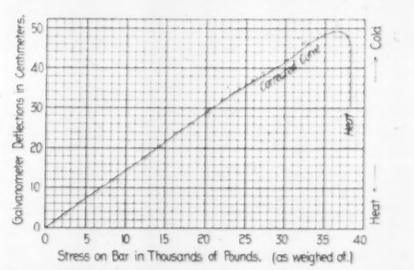


Fig. 2.—Thermal Stress Curve of Boiler Plate Steel Showing Accuracy of Results.

grade, and W, the weight in pounds per foot of the bar. That the thermo-electric method of measuring stress is fairly reliable may be shown by reference to Fig. 2, the dotted line showing approximately the corrected curve. The readings for this curve were taken last winter by Mr. Frank McIntyre and the writer.

If in the laboratory the temperature change caused by a change in stress of less than half a pound per square inch may be readily noted, it would seem no impossible task to make fairly accurate measurements of stress on some of our railroad structures, and thereby obtain some definite information regarding the effect of the shock and impact of trains at high speed.

Where there are compound stresses, as in the web of a girder, compressive and tensile stresses acting as an angle with each other, the heat evolved by the compressive stress neutralizes an equal amount of cold produced by the tensile stress, and we can only measure the difference which is sufficient to give us a very accurate knowledge as to the exact distribution of stress in this case. Thus, in the girder shown in Fig. 1, a series of measurements were made on the web along the neutral axis of the girder, marked heating effect was found in the plate near all stiffeners, denoting compression, and cooling effect denoting tension in the center of all panels.

This last determination may be regarded as an elegant illustration of the truth of Proposition III., Chapter XV., of "Modern Framed Structures." This proposition is given by Professor Johnson as a fundamental principle of the distribution of stress, and is well stated as follows: "When there are two or more paths over which a load may travel to reach the support, the load divides itself among the several paths strictly in proportion to the rigidities of the paths." Now, in our plate girder the path of greatest rigidity would be the line diagram of a Pratt truss, with the stiffeners for the posts and the flanges as chords, since the plate under and near the stiffener, together with the stiffeners, is better able to resist the compressive web stress than the plate between consecutive stiffeners.

Yours truly,

C. A. P. Turner.

Minneapolis, Minn., Aug. 17, 1898.

(In accordance with our usual custom proofs of the above letter were submitted to Mr. Wilson, and we append his reply below.—Ed.)

Sir: I have read with interest the correspondence on my letter of July 19 (Eng. News, Aug. 11, 1898) in reference to spacing stiffeners in plate girders.

One correspondent claims that "cutting slits in the web entirely changes the conditions, just as would be the case with a Warren girder of two or more systems of web members if one of the systems were cut." Now a Warren girder is a triangular truss, pure and simple, and one of several intersections becomes a lattice (without vertical stiffeners). Each member is a necessity for equilibrium and has its determinate stress. The development of the Warren girder or lattice, by making "n" intersections equal infinity, gives the rolled I-beam or built girder without vertical struts, the web being of sufficient thickness to resist compressive forces effectively and contributing its share in an appreciable degree to the upper and lower flanges. I believe there is no difference of opinion as to the proper method of treating such a girder. The Warren girder, however, is not at all analogous to the case under consideration, of a plate girder with thin web, requiring vertical stiffeners. It appears to be claimed by at least one of my critics that the tension in one diagonal direction on the web, so stiffens it that, no matter how thin the web, it cannot deflect under compression in the other diagonal direction, and actually acts to resist as a short prism independent of its length, and, I presume, the plate is considered as doing double duty, or perhaps even more, resisting diagonally by compression in one direction and by tension in the other, horizontally by compression in connection with the upper flange and by tension with the lower flange, and vertically by compression with the strut. While not going so far as this, there are engineers who include a portion of the web with the upper and lower flanges and with the vertical stiffeners, perhaps even allowing some compressive resistance in the web in the diagonal direction, and the last clause in my letter covers this point; but I do not consider it good practice. What may or may not be allowed is so uncertain, depending on the judgment of the engineer, which is not always reliable, and the economy gained is so little, that, in comparison with the obtaining of a first-class structure, it is not worth consideration, and in my own practice I would not allow a design made under such conditions. Such "finesse" in bridge calculation may do to talk about in high theory, but it will not answer in practical work where simplicity is demanded, even at the expense of a few more pounds of material.

Let us take a girder of, say, 5 ft. depth, with vertical struts at distances of 5 ft., making square panels. The diagonal of this panel is, say, 85 ins., and for a 3-16-in. web the length of the column for compression is 453 times its shortest diameter, or if a ⅜-in. web is used it would be 226 times. How much compression would such a column resist without deflection? and what amount of tension is required, at right angles, to prevent such deflection? It may be theoretically studied out, but what practical man would depend upon the result even if he felt confidence in the theory, knowing, as he does, the imperfections of manufacture. If I read aright, this is what is claimed. Even Rankine, who has been quoted, does not do so. I have before me an old edition, but I presume the latter ones are the same, and he says:

It is to be considered that the shearing stress at the neutral axis is equivalent to a pull and a thrust of equal intensity inclined opposite ways at 45°, and that the vertical web tends to give way by buckling under the thrust, so that its ultimate resistance in lbs. per square inch is given by the following expression:

$$\frac{36000}{1+\frac{s^2}{3000t^2}}$$

in which t is the thickness of the plates of the web, and s the distance measured along a line inclined at 45° to the horizon, between two of its vertical stiffening ribs.

In the present case, s = 85 ins., and t = 3-16-in., and we find the ultimate resistance to be about 530 lbs., one-sixth of which is, by Rankine, safe, equal to 88 lbs. per sq. in.

It will be noticed that Rankine makes no claim that the tension in the other diagonal allows him to ignore the length of the column. I am familiar with what Stoney says on the subject (p. 155), and his remark that such modes of construction are, however, more or less defective; also, under Internal Braced Pillars (p. 337), when he refers to the lattice bridge and says:

It is obvious, however, that long compression bars, even though formed of angle or T-iron, have but little stiffness in themselves, and we cannot trust to the tension bars keeping them in line of thrust at right angles to the former direction, for the tension bars may not always be in a sufficient state of strain.

It will easily be seen from the above figures what difficulties I labored under in my early engineering days in endeavoring to reconcile Rankine's method of calculation with the girders I saw in actual use.

It is customary in my own practice, and I presume also in that of others, to run the web through the girder in one piece, if it can be done, for the whole length of the girder; or if it must be spliced, it is done in the middle of a panel. The cast struts of former days were merely bolted through to keep them in place, and with wrought struts it is only necessary to rivet them sufficiently to secure them properly and firmly. The load on a strut is carried to the lower flange and by that distributed, as by a beam, of one panel length, to the web (center to center of panel), being resolved diagonally onto the web and horizontally on the lower flange. The diagonal stress is carried by the web towards the abutment to the upper flange, which also acts as a beam of one panel length, and it is resolved onto the next vertical strut and the upper flange, etc.

I have endeavored to enunciate what I consider a reasonable, practical method of computing thin web plate girders, without involving all the highly theoretical considerations which, while very beautiful, give litttle practical results of importance and may be entirely annulled by defects of manufacture. The short prism theory of resistance of web to compression I consider too uncertain to allow any practical dependence to be placed upon it where the lives of human beings may be placed in jeopardy.

I think if anyone will read that portion of my reply to the discussion on my paper on Bridge Specifications (Trans. Am. Soc. C. E., Vol. XV., p. 484), referring to plate girders, my position in the matter will be very clearly seen. Those specifications were written some years ago, and were among the first so published. Many changes and improvements have been made since then in my own work and specifications, as well as in those of others, but in this matter of plate girders my views remain the same.

Yours very truly,

Joseph M. Wilson,
M. Am. Soc. C. E., M. Inst. C. E.

Philadelphia, Pa., Aug. 31, 1898.

Notes and Queries.

The address is desired of Mr. W. H. Wood, who was at one time a Locating Engineer for the Union Pacific Ry., and was later employed in government survey.

C. S. asks: "Assuming a quantity of air enclosed in a tight tank together with and above a quantity of water; how much of the air will be absorbed by the water at different degrees of high pressure, say 3,000 to 8,000 lbs. per sq. in.?"

The amount of air absorbed would depend on the volume of the water and the time during which it was exposed to the air, perhaps also on the temperature.

THE RAILWAYS OF THE CRIPPLE CREEK, COLO., MINING DISTRICT.

By W. P. Hardesty,* C. E.

(With full-page plate.)

The Cripple Creek mining district is in El Paso county, Colo., the center being (in an air line) less than 20 miles southwest of Colorado Springs, which is on the main lines of railway between Denver and Pueblo. Perhaps no other mining region in the West is naturally so difficult of access as this. The elevation ranges from 9,000 to 10,000 ft. above sea level, and the district is surrounded on all sides but the west by high mountains. The summit of Pike's Peak is but nine miles to the northeast, this being the culmination of the Rampart Range, which separates the district from the plains country further east.

In 1891 attention was first drawn to the gold deposits of Cripple Creek, and within two or three years it was demonstrated that this was one of the greatest high-grade ore-producing districts in the world. The only communication with the outside world at first was by means of stages and freight wagons, the nearest railway point being Divide, on the Colorado Midland, 20 miles distant. The expenses of hauling supplies of all kinds from this station, and hauling out the ore, made it impossible during 1891 and 1892 to market ores that ran less than 2½ oz. in gold or $50 per ton. Nearly all of the product was shipped to the smelting works at Denver and Pueblo, and the cost of mining, transportation and treatment ranged from $30 to $35 per ton. In 1893 the output for the year reached $2,000,000, and it was seen that any railway reaching the district would have a very profitable business. In that year the survey for the first road, the Florence & Cripple Creek Ry., was made.

*612 Progress Building, Salt Lake City, Utah.

Florence & Cripple Creek Ry.

The locating engineer for this road was Mr. H. A. Sumner, who has had an extensive experience at such work in the West. The chief engineer is Mr. R. W. Stewart, with office at Florence. The road starts from Florence, on the Denver & Rio Grande Ry., and 32 miles west of Pueblo, and running northerly reaches the district at Victor, a distance of 34.6 miles. It continues on to the city of Cripple Creek, making its total length 40.3 miles. Construction was nearly all done during the first half of 1894, and on July 2 of that year the first train was run through.

The road is narrow gage, with a maximum grade of 4% compensated on curves at the rate of 0.02 ft. per 100 ft., and with a maximum curvature of 30°. There are many curves of this sharpness. It is a typical mountain road, and is one of the most recent examples of the class of mountain railways which were inaugurated by the Denver & Rio Grande Co. in the early '80's, and which so opened the eyes of the world as to the possibilities of railway location in rough country.

About eight miles from Florence the road enters Eight-Mile Canon, a narrow, tortuous channel that requires much skillful work to get through. The road as first built here lay along the bottom of the canon. During the first season an unprecedented flood came down the creek and washed out nine miles of track. The line was afterwards changed so as to run along the side, well above the creek, requiring much heavy construction on account of the difficult country. There are two short tunnels and a number of wooden bridges through this canon. The bridges often burn, so that the longest of them—a high trestle about 160 ft. to 180 ft. long, on the famous "Wilbur Loop"—has been lately replaced with iron to insure safety. This loop is made by the line doubling across the canon and running down the right-hand side of it till the summit of the ridge is reached, when it turns back and continues on its northerly course along the side of a different canon. The summit is reached at Alta Vista, only about three miles from Victor, and at an elevation of over 10,000 ft. The station at Victor has an altitude of 9,734, that at Cripple Creek is 9,396.

The track is laid with 45-lb. rails, which are being gradually replaced with 55-lb. rails. These weights for narrow-gage lines are greater than heretofore used. The engines are 40 tons weight; the passenger rolling stock is all new, but the freight cars were furnished by the D. & R. G. Ry. from its narrow-gage lines.

The Golden Circle R. R.

During the present year a road called the Golden Circle R. R. is being built from Victor to the town of Altman, on Bull Hill, which is said to be the highest town in America. The line goes directly past some of the largest mines in the camp, and the distance to Altman is about five miles, although it is but two miles by air line. Though different in name, the company building the railway is practically the same as the Florence & Cripple Creek Co. For the first mile or two there was much difficulty in securing right of way on account of other railway tracks crossed and in running close to certain mines, there being but little room to swing on account of the work being side-hill, and of the necessity of keeping up the maximum grade. It was necessary to pass through the dumping ground of the Portland mine—the largest producer in the district—and, on account of the enmity of the management of this mine towards the railway company, very stringent conditions were imposed in granting right of way. A covered way (to be gradually converted into a tunnel by the operation of dumping the waste from the mine) was necessary through the dumping ground, and, after considerable study, Mr. Stewart decided to make it of steel.

Steel Arch Tunnel.—The tunnel is of steel posts and arches resting on cast-iron piles. The width is 14 ft. and height 10 ft. to the springing line. The arch is semicircular with a 7-ft. radius. The piles on each side are spaced 8 ft. c. to c., except at each end, where it is 9 ft. The length of the tunnel is 242 ft. The piles are soft cast iron, 12 ins. outside diameter, 1 in. thick, and they were 6, 7, 8 and 10 ft. long, the average being 8 ft. A timber or log core was used in driving, the point of the pile being solid for about half its length. One or two were driven direct, by blows of the hammer on top. The tops were cut off even by a pipe-cutting machine. Cast-iron caps are put on top of the piles to receive the longitudinal I-beams, and the variation in line made in driving the piles is taken up by lead-filling between the flanges of beams and shoulders of caps. The weight on the tunnel is calculated at 11 tons per lin. ft., or 56 tons on each pile. The cost of these pile foundations was $7 per lin. ft. of tunnel. Each of the longitudinal sills for supporting the posts is composed of two 12-in. 31-lb. I-beams, having a bearing surface 12 × 14 ins. on each pile. The posts are spaced 2 ft. c to c., and each is of two 12-in. 31-lb. I-beams. Each half arch is made up of web and angles in three 4-ft. sections, spliced together with ⅜-in. plates; there is also a ½-in. plate on the outside of the angles at the springing line or connection with the post. Some trials were made at the Carnegie works of making the posts of sufficient length and bending them to produce the half arch part, but this produced minute fractures at the outer edges of the flanges, so it was not deemed advisable. The web parts of the sections have straight edges, but the angle iron flanges are bent to circular shape. For lateral bracing, an 8-in. I-beam crosses under the track at each two opposite piles, connecting the longitudinal beams. At the top of the arches is an 8-in. longitudinal beam between each two adjacent ones. At each side of the tunnel and running along at the springing line (on the outside) is an 8-in. channel iron. The roof covering and siding is of 3-in. red spruce. The cost of the steel work and the planking was about $50 per lin. ft. The intention is to brick in between the arches with two rings of brick when the boards shall have rotted out. The arches are set at right angles to the 4% grade, except the portals, which are set vertical. For 18 ft. at the lower end of the tunnel the arches are tilted to correspond to the track elevation for the 18 ft., which is in curve here, one sill being lowered and the other elevated. It is 22 ft. from the top of the arch to the original surface of the dump, and 15,000 cu. yds. of material had to be excavated to make way for the tunnel. The filling on the sides and top will be put on gradually, attention of course being paid to depositing the material so as to secure a fairly even pressure on the sides.

The calculation of the strains in the arches was done on the theory of a surcharged material on the sides and top, no allowance being made for packing. The material was called sand, and Baker's formula for side slopes of 1½ to 1 was used. The waste material from these mines usually packs much less than other material. It was calculated that the center of pressure would be at about the springing line of the arches.

The steel work was supplied by the Missouri Valley Bridge & Iron Works; but the erection was done by the railway company itself. The piles were cast at Pueblo. The railway company had other "tight places" to get through in this same vicinity, and there is a complicated overhead steel trestle crossing the Midland Terminal Ry.

Midland Terminal Ry.

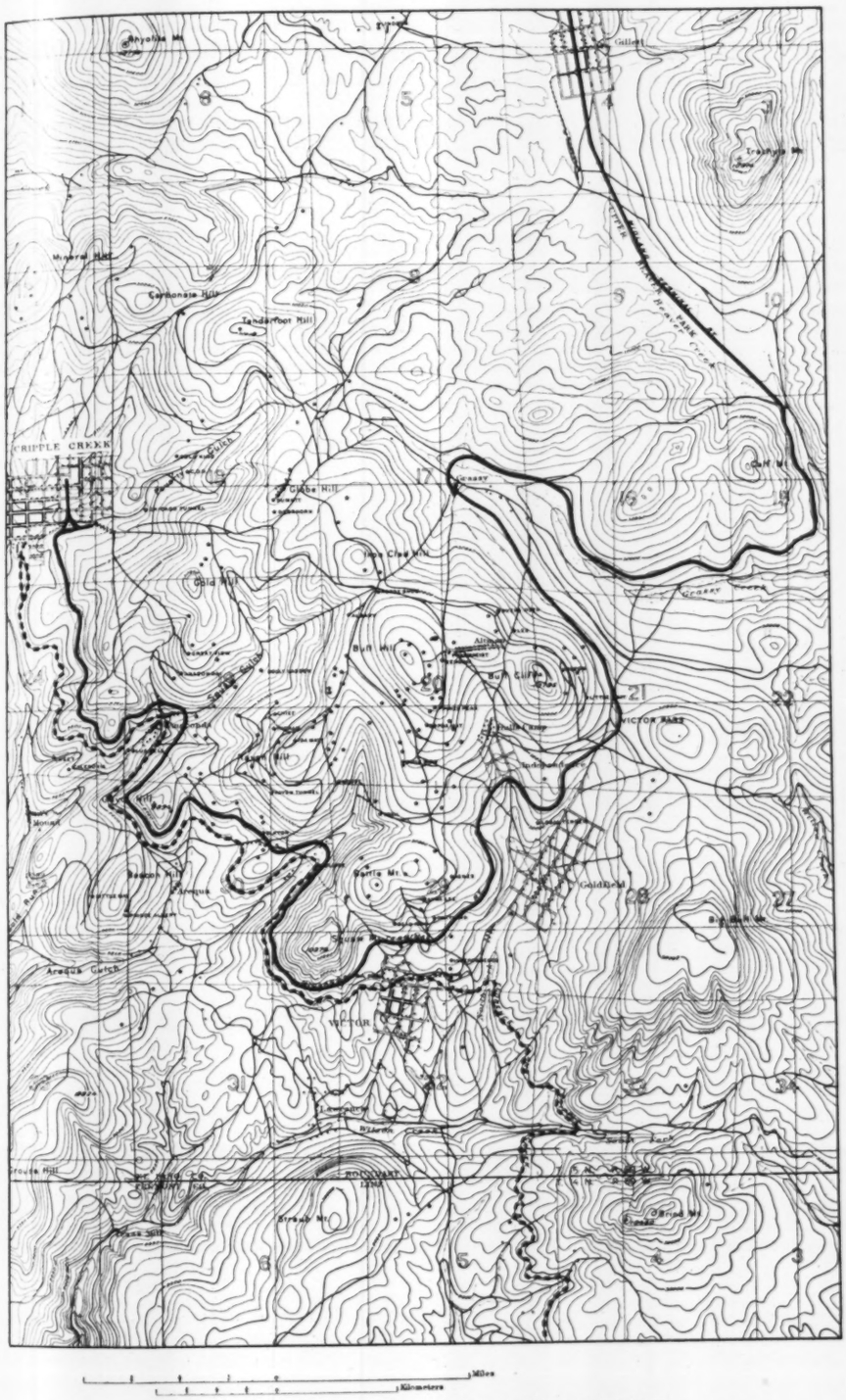
This railway runs south from Divide, a station on the Colorado Midland Ry. and at the summit of the main range here, and reaches Victor in a distance of 25 miles; then turning northwesterly it reaches Cripple Creek in five miles more. The road was completed in December, 1895. The maximum grade is 3%, except for about three miles of 4% grade north of the town of Gillette. The maximum curvature is 16°. Victor Pass, shortly before reaching Victor, is the highest point on the line—elevation, 10,225 ft.

The track is laid with 56-lb. rails furnished by the Colorado Midland Ry., that road having taken them up to lay heavier ones. The rolling stock is as heavy as any used on the main line, notwithstanding which very high speeds are at times reached. This is the only standard-gage road at present reaching the district.

The Cripple Creek District Railroad.

This is the highest electric railway in the world. It connects Cripple Creek and Victor, running directly over the top of the mountains between,

instead of running around them on a fairly easy grade line, as do the steam roads. It is a suburban road, and is intended to connect with a through electric line from Cripple Creek to Colorado Springs, when the latter shall have been built.



MAP OF THE CRIPPLE CREEK, COLO., MINING DISTRICT.

Reduced from a Map of the U. S. Geological Survey, published July, 1895, from surveys made in 1894. Datum, mean sea level; contour interval, 50 ft.

By running over the mountains the District Ry. reaches a part of the camp that the steam roads do not, and thus secures an excellent passenger traffic. The road was completed in December, 1897. The chief engineer was Mr. W. H. Leffingwell, M. Am. Soc. C. E., of Cripple Creek, and the projector and general manager is Mr. L. D. Ross, of Colorado Springs. The road is six miles long, it being three miles each way from the station at Midway on the summit of Horseshoe pass. There is about 1,000 ft. rise from Cripple Creek to Midway, at an altitude of 10,500 ft. On the southeast side the descent to Victor is only about 700 ft., though much development was required on this side the same as on the other.

There is considerable 6½ and 7% grade, and one piece of 7½% grade at the east edge of Cripple Creek. The 7½% was used because the line would have interfered with mining dumps if it had been thrown far enough into the hill to secure an easier grade. As it comes where the rails are made slippery in muddy weather by wagons crossing the track, it is difficult running over it, and much sand is used at such times. Curves as sharp as 60° or about 100 ft. radius are used. The track is elevated ½-in. per degree of curve up to 6 ins. The grade is compensated on curves at the rate of 0.03; 60-lb. rails are used. Three cars comprise the present rolling stock. These are each 40½ ft. long and weigh, with motors, 19 tons. Two 57-HP. motors are used, both at one end. There is but little platform room, one-half of the space for each being taken up by the vestibule for the motorman. In the vestibule is the controller and also the air brake compressor and appliances. The car has two four-wheel trucks, and 3-in. tread wheels are now used, but are to be replaced by 4-in. A second-hand Armington & Sims engine is at present used at the power station at Cripple Creek, and as it can work up to only 175 HP., only one car at a time can be drawn up the hill. Two are run regularly, one always descending. A 6-pole dynamo is used, and the current goes out over the 2-wire feeder line at 550 volts, reducing to 480 and 450 on the line, however. This feeder line runs directly across the country and is tapped where it crosses or comes near the track—about ten times. The trolley wire is No. 00. The bonds for rail joints are No. 0000, No. 00 being found too light.

The cars have a seating capacity of 40, though 100 people are often carried at a load. Immediately on starting down hill the air pump is started going. Straight air is used, the pressure in the cylinder being kept at 70 to 80 lbs., while the average pressure applied is about 30 lbs. The steel brake-shoes used wear out in about three weeks. During the winter, when a snow storm is in progress, a car is kept running all the time to keep the track clear, the track-scraper being used.

The District Ry. is only a connecting link in an electric road that is intended to run from Colorado Springs to Cripple Creek. This line will join the portion already built at Midway on top of the pass. It will be 28 miles long, 14 miles each way to Colorado Springs and to Midway from the divide or summit of the Rampart range. The elevation of this pass is 10,200 ft. The maximum grade will be 7%. The engineer is Mr. H. I. Reed, of Colorado Springs. The preliminary survey from Colorado Springs runs up Bear Creek canon to the divide, where there is now being erected a water-power station. As is well known, the city of Colorado Springs obtains a large part of its water supply from the slopes of Pike's Peak in this vicinity, and the extremely high altitude of the heads of the supply allows of a great fall being used for power purposes, even at this great elevation. By an agreement with the city, the railway company has the right to take water from the former's main supply pipe here, the water to be returned to the city's system further down. A fall of 700 ft. in less than half a mile is secured, sufficient for the development of 600 HP.

From the divide over to Midway the distance by the transmission line is 8 3-10 miles. This line and the transformer station at Midway, with its three step-down transformers and switchboards, are now completed. The transmission is three-phase, three-wire, and the voltage is reduced from 6,300 to 550 volts at the station. There are to be two more power stations built on the west side of the divide, but whether for steam or water power is not yet known, it depending on the developments regarding supplies for the last. Through the inhabited portions of the country traversed by the road, the usual overhead trolley system will be used, but for the remainder of it the third rail system will be used. The cars will be so constructed that they can be attached to any steam railroad train. There are intended to be 30 trains a day, ten passenger and five freight each way—the running time of the former between Cripple Creek and Colorado Springs will be a little over one hour.

At Colorado City (2½ miles west of Colorado Springs) it is proposed to build a number of new reduction works to treat the vast quantities of low grade ore that it will then become possible to ship.

THE SUBSTITUTION OF ELECTRICITY IN PLACE OF STEAM ON A BRANCH OF THE ERIE R. R.

A recent example of the use of electricity as the motive power on a road previously operated by steam locomotives is the railway which runs from Tonawanda to Lockport, N. Y. The road is operated by the Buffalo & Lockport Ry. Co., and serves as a feeder to the Erie R. R. The company was organized in April, 1898, and immediately purchased about 5½ miles of single track running through Lockport, and leased for 99 years the Lockport branch of the Erie R. R., consisting of 13½ miles of single track from Lockport to North Tonawanda. In addition, 7½ miles of single track between Buffalo and North Tonawanda and one mile in the city of Buffalo were purchased. In this way 29 miles of tracks were acquired, all of which were equipped for electric traction.

This work involved the erection of poles, overhead trolley, feeders and the bonding of rails, and was begun May 17, 1898. On Aug. 14, almost exactly three months later, trains were in operation by electricity.

Both passenger and freight service is given, the former by running separate electric cars on half-hour headway. The freight service is handled by two electric locomotives. There are 10 electric motor cars, built by J. G. Brill Co., Philadelphia, Pa. These are mounted upon eight wheels, using two "Perfect" trucks. These are of two kinds, a combination passenger and smoker, 42 ft. long over buffers and 31 ft. long between ends, with 4½-ft. platforms, and a combination passenger and baggage car with a body length of 31 ft. 8 ins. and 4½-ft. platforms. The motor equipment consists of four G. E.-57 motors (208 H.P. per car) and two B 8 series parellel controllers. The total weight of a loaded car is from 20 to 25 tons.

For handling the freight, two 36-ton electric locomotives have been furnished by the General Electric Co. One of these, hauling a train of cars, is shown in the accompanying illustration. In general appearance they resemble the well-known Baltimore & Ohio electric locomotives and the one used on the Hoboken Shore Road, described in Engineering News for July 11, 1895, and Jan. 13, 1898, respectively. The design follows closely that of the locomotives just mentioned, sloping shields being placed on each side of a central cab, and the whole carried on two four-wheel trucks. The cab frame is made of 1¾-in. × 1¾-in. angles, covered with a sheathing of ⅛-in. iron. The main frame is built up of 8-in. channels, running the entire length, and securely riveted to cross plates at the ends directly over the center truck bearings. Heavy oak buffer beams, to which are attached draw-heads and pilots, are secured to the ends of the platform. The trucks have swing bolsters, supported by elliptical springs, and the truck frames are built up of forged and rolled iron securely bolted and riveted together, the pedestals being made of cast steel. The truck proper rests on coil springs, supported by equalizing bars. The wheels are 36 ins. in diameter, with steel rims and iron centers. The locomotives are each equipped with four GE-55 motors. The draw-bar pull at full speed is approximately 3,400 lbs., sufficient to handle a 340-ton train at about 15 miles per hour. The motors are rated at about 160 H.P. each, or a total of about 640 H.P. As the maximum speed required is quite low, two motors are at all times connected in series.

The controller is of the K-24 type, with cut-out wiring, modified to fit the special requirements of the equipment in regard to speed. Outside, the resistance points only two combinations of the motors are possible, the first throwing all four motors in series, and the second, or running position, placing motors No. 1 and No. 3 in series and the pair in multiple with motors No. 2 and No. 4 similarly connected.

The locomotives are equipped with pneumatically controlled trolleys. With this arrangement it is no longer necessary for the engineer or helper to leave the cab and replace the wheel on the wire or reverse the trolley. This is effected by a handle conveniently placed over the engineer's head. The downward motion is obtained by admission of air to a cylinder, the piston of which in moving compresses the spring, holding the pole in place while running. The upward motion is accomplished by the spring and the movement sideways by hand, both pole and handle being on a swivel plate.

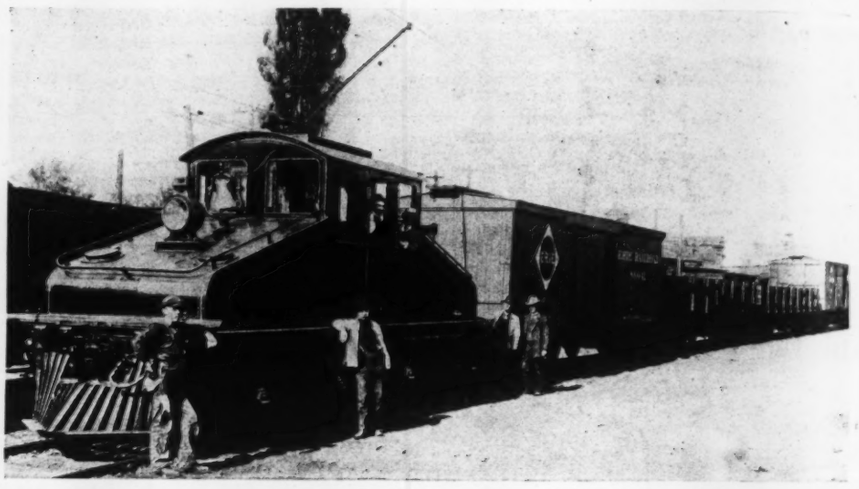
The balance of the equipment consists of air-brakes, whistle, bell, air-blast sanding device, air pump, magnetic circuit breaker, magnetic switch, lightning arrester, electric lights, etc.

The following are the principal dimensions of these locomotives:

Length over all	32 ft.
Height of cab over rails	12 ft.
Distance between centers of trucks	13 ft.
Wheel base (one truck)	6 ft.
Gage	4 ft. 8½ ins.
Diameter of wheels	36 "
Complete weight of locomotive	36 tons.

The locomotives have already been subjected to several severe tests. They are specified to be capable of hauling trains of 300 tons weight, exclusive of the locomotive; but they have already proved themselves equal to hauling as many as 28 loaded freight cars at the specified speed of 15 miles an hour.

To obtain the necessary current the transmission line of the Niagara Falls Power Co. was tapped between the Niagara Falls power house and Tonawanda. A special transmission line, using cedar poles, triple petticoat insulators and No. 0000 (B. & S.) bare copper wires, carries the current to a rotary converter sub-station at Lockport. This building contains six 150-K-W. air-blast transformers, which drop the voltage from 10,500 to 350 volts, and two General Electric 6-pole 400-K-W. 500-revolution rotary converters, taking alternating current from the transformers, just mentioned, and converting it into direct current at 500 volts.



640-HP. ELECTRIC LOCOMOTIVE FOR THE BUFFALO & LOCKPORT R. R.
General Electric Co., Schenectady, N. Y., Builders.

The switchboard is of the standard panel type, and consists of one panel for the high potential transmission, two panels for the low-tension alternating current side of the rotaries, two "K" direct-current railway panels for the direct-current sides of the rotaries, and two transformer panels. The switches for the high-tension current are of the quick-break type, each blade being separated from its next neighbor by a marble barrier. The blades are pulled open by means of a hooked stick, the hook being inserted in an eyelet into the end of the blade.

Another sub-station, also taking current from the Niagara Falls plant, will soon be built at Tonawanda, the intention being to operate the road in sections. The first of these sections, from the starting point in Buffalo to the city limits, will take current from the Buffalo Railway Co.'s station in Buffalo. From there to Lockport, a distance of seven miles, and half way to Niagara Falls, and half way back to Tonawanda, will be operated by the converters at Niagara Falls. It is also the intention that the Buffalo & Lockport road will either give to or take current from the Buffalo & Niagara Falls Electric Ry., should occasion arise.

The officers of the new company are: Pres., Mr. W. Carl Ely; Manager, Mr. Burt Van H[illegible]n; Superintendent, Mr. C. K. Marshall. The operating officers are the same as those of the Buffalo & Niagara Falls Electric Ry.

We are indebted to the General Electric Co. of Schenectady for the illustration and data from which this article has been prepared.

DISCHARGE REGULATOR AND TESTS OF 14-IN REDWOOD WATER MAIN, NEAR LOS ANGELES, CAL.

The West Los Angeles Water Co. recently built a line of 14-in. redwood water main, 37[illegible] ft. long, to supply the National Home for Disabled Volunteer Soldiers near Santa Monica, Cal. This main is an extension of the Holywood pipe system of the company, and is shown in profile by Fig. 1. In order to avoid as much heavy pressure as possible the line follows the hydraulic gradient as closely as is feasible; and to prevent the full static pressure coming onto the pipe the flow into the same is controlled by a balanced valve operated by a float. Between this structure at Sta. 22 and Sta. 145 water is distributed to many consumers for irrigation and domestic use. From the latter station the line is built exclusively for the supplying of the Soldiers' Home. The contract with the Government authorities for this supply specified that the water should be delivered into a reservoir at the Home at a uniform rate of 348 gallons per min. To accomplish the fulfilment of these conditions from a pipe system subject to constant fluctuation of pressure, without governing the flow at the extreme end of the extension, thereby subjecting the entire pipe to a maximum pressure due to the full static pressure limited only by the elevation of the structure at Sta. 22, was a problem whose solution required something different from any appliance yet devised. To meet this requirement the automatic regulator, Fig. 2, was devised, and may prove of interest to your readers, especially as use has demonstrated its ability to perform perfectly the function required. The device needs little explanation to make its working plain. The telescopic adjuster can be set for any desired head on the weir, when the water will stand just high enough over the lip of the adjuster to admit the passage of such a quantity into the balancing pan, through the hose connection, as will supply the amount passing through the small leak hole in the bottom of the pan, and at the same time retain such an amount in the pan as will constitute an equilibrium when its weight is opposed by the weight of the valve, the movable cast-iron ball and the tension of the spring at the other end of the lever. So long as there is no change in the pressure of the water above the regulator, it is evident that this condition will continue indefin-

itely. Any disturbing of the equilibrium is only temporary, as the apparatus at once restores it. Thus, if there is a sudden increase of pressure, it at once results in an increase in the height of the water on the weir, a corresponding increase in the rate of flow into the pan, and a consequent partial closing down of the valve until the requisite head on the weir, for which the adjuster is set, is again restored. Should there, on the other hand, be a sudden decrease in the pressure by reason of heavy drafts above, the water fails to run into the balancing pan, that already in, leaks out until the diminished weight is accompanied by an increased opening of the valve through the action of the opposing weight and spring. The weir is not intended to conform to the correct theory for accurate measurement, it being placed for convenience quite near the valve, which results in more or less disturbance of the water. Its error is determined by use of an accurate weir located at the lower end of the line at the point of discharge into the reservoir, and is allowed for in setting the adjuster. There are no new principles in this device, but the general combination is believed to be wholly new.

The following observations made on the carrying capacity of the line to determine the coefficients of discharge may also be of interest:

Section.	Length, ft.	Average diam., ins.	Loss head in 1000 ft.	Lin. vel., ft. per sec.	Value of C in V = C√RS
D to E.....	4,825	14.05	0.170	0.698	99
G " H.....	3,436	14.075	0.161	0.695	101
A " B.....	8,931	14.05	0.178	0.751	104
C " D.....	4,403	14.11	0.145	0.691	105
F " H.....	9,912	14.05	0.391	1.167	109
F " B.....	.....	.....	0.638	1.531	112
A " B.....	8,931	14.05	0.375	1.181	113

The losses of head were determined by observations made from the open stand-pipes and other structures on the line; and the volume of discharge by weir measurement at the terminus of the line. The weir itself was checked by volumetric measurement in the reservoir itself. The average diameter of the pipe line was determined by many measurements made during construction. It will be observed that the velocities experimented with are all very low, such as usually give results least concordant. Considering that five different sections were experimented on, the disparity in results secured are not bad for these velocities. The corresponding values for "n" in the Kutter formula are between 0.010 and 0.011, being nearer the latter than the former.

Mr. Arthur L. Adams, M. Am. Soc. C. E., is engineer and manager of the West Los Angeles Water Co. The office of the company is at 405½ Broadway, Los Angeles, Cal.

THE PROPOSED FLOATING DRY-DOCK AT ALGIERS, LOUISIANA.

Proposals are now invited, by Commodore M. T. Endicott, U. S. N., Chief of Bureau of Yards and Docks, for the construction of a combined floating and graving steel dry-dock, to be located at Algiers, La. The bidders are asked to submit full plans and detail specifications, with their proposals, on or before Oct. 31, 1898, and the limit of cost for the entire work is fixed at $850,000.

The Bureau submits a general specification as a basis for the presentation of plans, etc., and from this the following abstract is made: The proposed dry-dock is to be capable of lifting a vessel of 15,000 tons displacement and 27 ft. draft of water, and the cost named is to include the dock, moorings and wharf. The length of the floating steel dock is to be 525 ft. over all, with 28 ft. of water over the keel blocks and a clear width of not less than 100 ft. If the dock is of the balanced type, it must be so designed as to admit of examination and repair in all its parts, with ease and safety; it must lift a 15,000-ton ship above the level of the river, with a freeboard of not less than 2 ft., and the entire structure must be of steel, excepting the keel-blocks, bilge-blocks and shores. If, however, the design calls for any portion of its accessory structure that is entirely beneath the water surface, such portion may be of wood. To operate the dock, steam, electric, hydraulic or pneumatic power may be used.

It is the purpose of the Bureau to give full latitude of design to the bidder; provided, that the design submitted fully meets the requirements of the naval service for the safe docking of the specified size of ship. To this end stress diagrams must be submitted, based upon standard diagrams furnished by the Bureau, and giving the length and distribution of weights in the heaviest U. S. battleship. These diagrams call for a battleship 450 ft. long, weighing 15,000 tons, and having two-thirds of this weight concentrated in the middle half of her length.

If the dock is designed as a single structure, it must be strong and stiff enough, longitudinally, to safely distribute the load over the entire length, if the vessel be docked in one end of this structure; if the design calls for a sectional dock, adequate provision must be made for so connecting the sections that the dock may act as a unit, and the sections be kept level without straining the ship; and if one of the sections should lose its buoyancy, the connections of the sections must be capable of distributing over the remaining sections the weight of the injured sections and all parts of the ship over this section. The dock must not careen more than 3° under the most unfavorable conditions of loading; providing for the vessel landing 2 ft. off the longitudinal center line, and subject to wind pressure of 30 lbs. per sq. ft. The greatest longitudinal deflection permitted will be 1 in. in 3,000, with the most unfavorable load; the greatest transverse deflection must not exceed 1 in 1,800, under similar conditions.

This dry-dock must be completed in 18 calendar months from the date of signing the contract; and proposals must be accompanied by a certified check for $15,000 as a guarantee to commence work within ten days, if contract is awarded; and there will be a bond equal to 20% of the contract price. A penalty of $200 per day will be exacted for delay in fulfilling the contract. The steel specified is acid or basic open-hearth, and the tests of this steel are fully specified.

The specifications give the following data referring to the stages of the Mississippi River at New Orleans, La.:

Zero of gage is 2.53 ft. below mean gulf level.
Zero on the gage is low water of Dec. 30, 1876.
High water of April 16, 1874, reads 16.2 ft.
High water of May, 1897, reads 19.5 ft.
The danger line was changed from 13 to 16 ft. March 15, 1897.

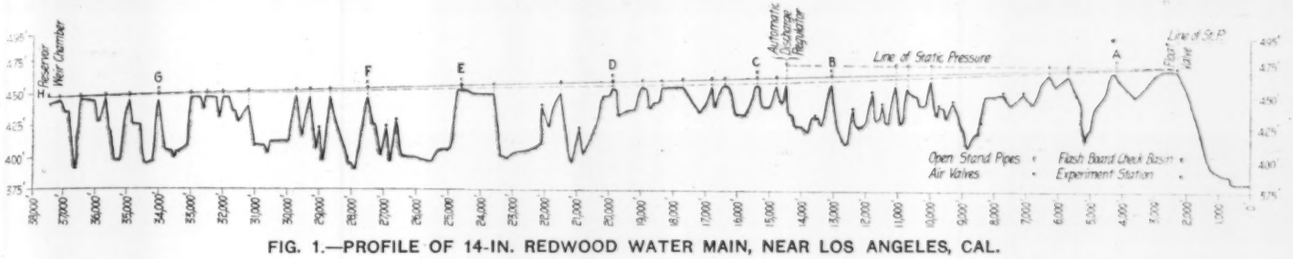


FIG. 1.—PROFILE OF 14-IN. REDWOOD WATER MAIN, NEAR LOS ANGELES, CAL.

COMPRESSED AIR AND ELECTRICITY AT THE LASSIG BRIDGE & IRON WORKS.

An interesting change is being made in the equipment of the plant of the Lassig Bridge & Iron Works, of Chicago, Ill., by which the use of line shafting will be dispensed with, and all the tools will be operated by compressed air or electricity, according to which power is best adapted for each particular purpose.

The compressed air plant, which is shown in the accompanying illustration, consists of a duplex Corliss air compressor, with two-stage or compound cylinders for the compression. The steam end is composed of two simple Corliss engines of 200 HP., placed side by side, and connected to crank disks on a flywheel shaft, the cranks being set at 90°. Tail rods from the steam cylinders operate the air cylinders. The steam cylinders are 20 x 30 ins., and the air cylinders are 18¼ x 30 ins. and 30¼ x 30 ins.

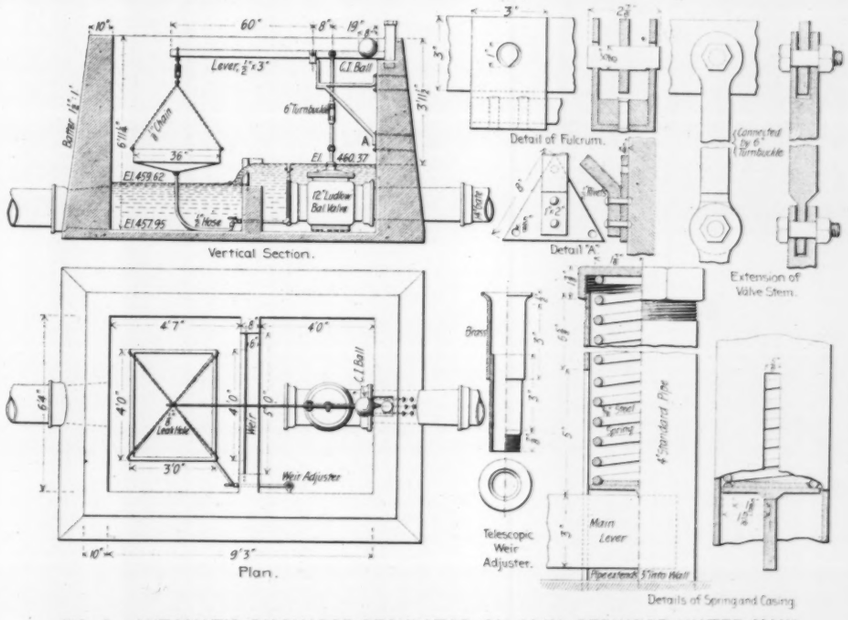


FIG. 2.—AUTOMATIC DISCHARGE REGULATOR ON 14-IN. REDWOOD WATER MAIN.

From the low-pressure cylinder the air passes to a vertical intercooler of the receiver type, having sufficient capacity to fill the high-pressure cylinder without any drop in pressure. This intercooler, which may be seen between the windows, is 42 ins. diameter and 11 ft. high. The air enters at the center of the top and passes down through a cylindrical chamber extending about two-thirds the depth of the receiver, and being open at the bottom. In this chamber is a nest of 1-in. vertical tinned brass tubes, through which an upward current of water is maintained. The cooled air passing out at the bottom of the chamber fills the receiver, and is taken out near the top of the receiver by a pipe leading to the high-pressure cylinder of the compressor. In this way the air from the low-pressure cylinder at about 240° is reduced to the temperature of the surrounding atmosphere before it enters the high-pressure cylinder. From this latter cylinder the air passes to the vertical reservoir shown in the corner of the room. The air pressure is 30 lbs. per sq. in. in the intercooler and 80 lbs. in the reservoir, the compressor having a capacity of 2,200 cu. ft. of free air per minute compressed to a pressure of 80 lbs. per sq. in.

To ensure economical working of the engine, it is desirable to maintain a practically constant pressure of 80 lbs. in the reservoir, and this is effected by means of a sensitive regulator of the diaphragm type, whose rod is connected to the governor rod, and changes the cut-off of the valve gear. In this way the economy of the Corliss engine is realized much better than by throttling the steam, and the governor has little to do except to speed up the engine when there is a heavy demand upon the reservoir.

In the caps of the main shaft bearings may be seen small stud screws. There are four of these to each cap, tapped through into the pedestals, and their purpose is to take the weight of the cap, and thus relieve the shaft of the weight. The heavy pipe across the engine room is the steam main, supplying the engines of the air compressors and electric dynamos, and it may be explained that as another engine was to be erected side by side with the one shown, it was necessary to take the photograph before the magnesia covering had been applied to the pipes.

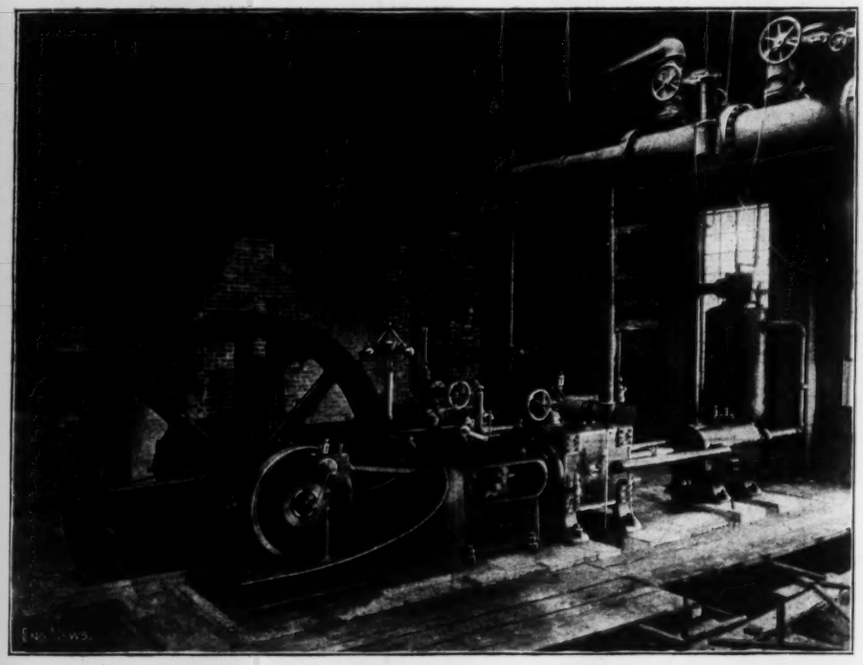
This air-compressor plant was put in by the Ingersoll-Sergeant Drill Co., of New York, and we are indebted to the Chicago office of the company for the photograph reproduced herewith. The plant will supply power for the following tools and appliances: 15 air riveters, 11 × 9 ins.; 6 rotary air drills; 6 pneumatic hammers; 4 rivet furnaces, and 36 oil heating furnaces.

The electrical equipment was planned by Mr. F. Sargent, of Sargent & Lundy, Chicago, Ill. The power plant will consist of a dynamo of 200-K-W. capacity, driven by a Corliss engine, and furnishing current to motors driving the following tools and appliances:

26 punch presses,	1 paint mixer,
4 cranes,	1 milling machine,
1 derrick,	1 link boring machine,
1 plate roll,	1 radial drill,
1 bending roll,	1 pair emery wheels,

4 batteries of radial drills, carrying 45 bits, for holes 11-16-in. to 1⅛ ins. diameter.

All the work has been done under the supervision of Mr. Emil Gerber, M. Am. Soc. C. E., Chief Engineer of the Lassig Bridge & Iron Works.



DUPLEX CORLISS TWO-STAGE AIR COMPRESSOR AT LASSIG BRIDGE & IRON WORKS, CHICAGO.
Ingersoll-Sergeant Drill Co., Builders.

THE SANITARY PROTECTION of the small lake which supplies water to the fashionable resort of Tuxedo, N. Y., contains one feature which is probably without a parallel. This is the provision that any person falling overboard from a boat on the lake is arrested and fined $25. Bathing in the lake was first prohibited, but its limpid waters were so tempting to the boys of the vicinity that in order to enjoy a dip they would contrive to fall overboard when out on the lake. The ordinance in question was therefore adopted to meet this practice, and it is said to be entirely successful.

MUNICIPAL OWNERSHIP OF WATER-WORKS in Des Moines, Ia., was defeated in a popular vote taken on Aug. 28. The vote was light, only 7,500 out of 25,000 voters, and the proposition to purchase the works of the Des Moines Water Co. was defeated by about 150 votes. One reason for the defeat is said to have been that taxpayers considered the price asked by the company exorbitant, and objection was also made to the quality of the supply.

A WATER POWER PLANT IS TO BE CONSTRUCTED at Wrightsville, Pa., by the Martic Water & Power Co., Mr. James H. Harlow, Chief Engineer. The work will include about 22,000 cu. yds. of excavation, 10,000 cu. yds. of masonry, 830,000 ft. B. M. of timber, and the furnishing and installation of 24 turbines with shafting and all other appurtenances complete. Plans, specifications and blank forms for bids can be obtained from the engineer after Sept. 15, as stated in our advertising columns.

THE CONTRACT FOR WATER METERS required by the city of Chicago, from June 17, 1898, to May 1, 1899, is held by the Pittsburg Meter Co., of Pittsburg, Pa. The life is guaranteed for 10 years for meters up to 2 ins. in size; and two years for larger sizes. The accuracy must be within a limit of 3% for five years, during which time the contractor is to keep them in repair. They are to withstand a pressure of 200 lbs. per sq. inch. The number, sizes and prices are as follows:

Diameter, ins.	Number.	Price per meter.	Total price.
⅝	200	$6.95	$1,390
¾	200	10.00	2,000
1	200	13.00	2,600
1½	200	25.00	5,000
2	100	40.00	4,000
3	100	80.00	8,000
4	20	160.00	3,200
6	20	325.00	6,500
Total	1,040	....	$32,690

THE BROOKLYN BRIDGE TROLLEY ACCOMMODATIONS will be increased by the addition of two new loop tracks at the New York terminal. These two new loops, according to the plans, will be situated about 100 ft. distant from the present loops towards Brooklyn, and will necessitate the removal of one stairway and a part of one gallery, as well as the present electric lighting plant of the bridge. The engineers of the bridge and those of the railway companies are also considering plans for improving the terminal facilities at the Brooklyn end of the bridge, but as yet have not reached any very definite conclusions.

THE RESURVEY OF CHESAPEAKE BAY by the U. S. Court and Geodetic Survey has been nearly completed during the present season. This resurvey had been contemplated for several years, as the shore line and bottom of the bay had undergone many changes since the original survey, 50 years ago, but its immediate accomplishment was due to the fact that the work of harbor defence compelled the concentration of this coast survey work in some locality where there would be no fear of interruption, and Chesapeake Bay was the locality selected. The work of the resurvey has been in charge of Capt. Herbert G. Ogden, who has had eight parties, comprising altogether 24 officers and 100 men, employed throughout the season.

AN AMERICAN PACIFIC CABLE from America to the Hawaiian Islands, the Ladrone Islands, Manila and Japan is just now being much talked about in the daily press. The Pacific Cable Co., which already has a license from the Hawaiian government for a cable between those islands and America, has, it is stated, sent its representatives to Japan to make the final contracts with that country if possible. This same company is also stated to have ordered surveys to be made for a duplicate or reserve cable to run from Sitka, Alaska, by the Aleutian Islands, to Japan. The estimated cost of the two cables is between $22,000,000 and $25,000,000.

THE COLLECTION AND DISPOSAL OF THE GARBAGE of New York city has recently been made the subject of investigation and report by a special committee of the Board of Health, consisting of Dr. G. W. Martin and Dr. James B. Taylor. The investigation was made upon complaint that the disposal of garbage as carried out at Barren Island was becoming a nuisance and the committee reported that the nuisance had in fact become as bad as it was last year, when a strong protest was made against it. It recommended that the Sanitary Code be amended so as to compel the removal of garbage from the city every twelve hours to the place of disposal, to prevent any boat or barge used in the removal of garbage from being tied up at any city pier longer than twelve hours at a time, to have these boats covered so as to prevent the escape of bad smells, and to provide that garbage must be deodorized. The committee also recommended that the windows, doors and skylights in the buildings on Barren Island be kept closed at all times, and the air necessary be forced in by fans and drawn out by pumps, duplicate sets of the latter being required, so that the breaking of any would not require the opening of the windows. The Board adopted the report unanimously and directed the Corporation Counsel to amend the Sanitary Code to cover these recommendations. President Murphy was also empowered to revoke the permits of companies on Barren Island who do not immediately comply with the new rules.

A NATIONAL ASTRONOMICAL SOCIETY is about to be organized in this country. Heretofore the astronomers have been in the habit of meeting together once a year at the annual meetings of the American Association for the Advancement of Science, they constituting a large part of the membership of Section A, Mathematics and Astronomy. The number of observatories and the number of men now devoting themselves to astronomical research make the formation of a separate astronomical society advisable. It is probable that the new society will be one of the "affiliated societies" of the American Association for the Advancement of Science, which hold their annual meetings at the same time and place. The present tendency of the old society seems to be toward disintegration into "affiliated societies," but this tendency is no doubt a benefit to the "Advancement of Science."